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OF THE

New England Water Works

ASSOCIATION.

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OF THE

New England Water Works

ASSOCIATION.

1893-94.

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NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. VIII. September, 1893. No. 1.

This Association, as a Body, is not responsible for statements or opinions of any of its members.

PROCEEDINGS OF THE TWELFTH ANNUAL CONVENTION.

WORCESTER, MASS., June 14, 15, and 16, 1893.

The sessions of the Twelfth Annual Convention of the Association were held in Horticultural Hall, Worcester, Mass., on Wednesday afternoon and evening, June 14, and on Thursday forenoon and evening, June 15. The headquarters of the Association were at the Waldo House, the Bay State House, where the preliminary arrangements for accommodations had been made, having been damaged by fire a few days before the date of the convention.

AFTERNOON SESSION.

WEDNESDAY, June 14, 1893.

President Chace called the convention to order at 3 P.M., and presented His Honor Henry A. Marsh, Mayor of Worcester, who spoke as follows:

ADDRESS OF WELCOME BY MAYOR MARSH.

Mr. President and Members of the New England Water Works Association: It gives me great pleasure in behalf of the citizens of Worcester to welcome you. Worcester, as you know, is called the "heart" of the Commonwealth. We are proud in the knowledge of the fact that it is the second city in the State, and perhaps, as some of you are strangers here, I may say a word about our city. I am often asked why it is that Worcester, being located as it is forty-five miles from tide water, is so prosperous. It has a population to-day of nearly 100,000. The secret of its great prosperity is largely in the fact that its railroad facilities are unsurpassed, five different lines entering the city. Another fact of importance is the wonderful diversity of its mechanical interests, nearly all of which are maintained by resident capital, so that the money that is made in Worcester is spent here. In your drives about the city you will be pleased, I know, with the great number of attractive looking houses you will see, not only of the capitalists,

but of the workingmen of Worcester. Our water-supply is obtained from two independent sources, each of which is in itself ample for the domestic and manufacturing purposes of the city. The quality of the water is of a high standard, far above the average, of purity, and the service for fire purposes is probably unsurpassed by that of any city in New England. You see we have very much to be grateful for, and I wished to say at least so much about our city in opening.

I applaud heartily the objects of an association like yours. Your meetings cannot fail to be pleasant and profitable. They are pleasant in the renewal of friendships and the making of new acquaintances; they are profitable in the opportunity for the interchange of information upon subjects in which you are all interested. In these days of progress and of competition, in these days of great advance in applied sciences, men cannot be too well informed on the branches of industry in which they are engaged. Your association, with its instruction and mutual exchange of ideas and knowledge, does more than anything else I can think of to improve the water works departments of our cities and towns; and we are glad you have chosen to visit us this year.

The committee on the part of the city government have authorized the Water Commissioner and the Registrar to entertain you, and they have arranged a programme which I hope can be carried out to the letter. Messrs. Brady and Batchelder are the two busy B's in our water department; you probably know them well. If they desire any further assistance from either the committee or the Mayor it shall be forthcoming. I am glad the clouds have cleared away, and I hope the sun will shine during your entire visit here, and that you will take with you to your homes none but the pleasantest impressions of our beloved city. (Applause.)

The President called for the regular order of business.

On motion of the Secretary, the reading of the minutes of the last meeting was dispensed with, they having appeared in the printed pages of the JOURNAL.

ELECTION OF MEMBERS.

The Secretary read the following names of applicants for membership, all of whom had been properly endorsed and favorably considered by the Executive Committee:

RESIDENT ACTIVE MEMBERS.

George E. Crowell, proprietor Water Works, Brattleboro', Vt.; Andrew B. Goodier, Treasurer and Superintendent, Southbridge, Mass.; Horace Kingman, Superintendent, Brockton, Mass.; William J. Luther, Superintendent and Registrar, Attleboro', Mass.; George L. Merick, Civil Engineer, Everett, Mass.; Joseph E. Selfe, Water Commissioner, Wellesley Hills, Mass.; F. J. Shepard, Treasurer, Derry, N.H.; John C. Sullivan, Registrar, Holyoke, Mass.

NON-RESIDENT ACTIVE MEMBERS.

B. A. Eardley, Registrar Pacific Improvement Company's Water Works, Pacific Grove, Monterey County, Cal.; William E. Griffith, Secretary Water Commissioners, Cumberland, Md.; W. S. Lea, McGill University, Montreal.

Quebec; Fred H. Pickles, Engineer and Superintendent, Winona, Minn.; William B. Taft, Civil Engineer, Glen's Falls, N.Y.; W. G. Zich, Superintendent, Waterford, N.Y.; A. Prescott Folwell, Civil Engineer, Atlantic Highlands, N.J.

ASSOCIATE MEMBERS.

Neptune Meter Company, "Water Meters," 408 Temple Court Building, New York city; Benjamin C. Smith, Agent French's Pipe Cutting Machine, 275 Pearl street, New York city; Weir Meter Company, "Water Meters," 7 Dodge street, Salem.

On motion of Mr. Philbin, the Secretary was directed to cast the ballot of the Association in favor of the admission of the applicants, and they were declared elected members.

President Chace's annual address was as follows:

ADDRESS OF PRESIDENT CHACE.

Brethren of the New England Water Works Association: It is with deep regret that I have to announce that we have lost one of our number by death since the last meeting. Augustus W. Locke, of North Adams, Mass., died May 14, 1893, at the age of forty-six. He had been a member of this Association since June 13, 1889, and was also a member of the Boston Society of Civil Engineers. He was an able and genial man, much beloved by those who knew him well.

It has been customary for the President, at the Annual Meeting, to give in his address a summary of the work of the Association. But the work of the past year is known to the members through the issues of the JOURNAL, and its growth in numbers and financial resource is shown by the reports of the Secretary and of the Treasurer.

The members know the value of the organization; they know its work. How shall its value become better known to the public at large, and its influence be extended?

The organization began with a meeting of twenty-one water works superintendents and registrars at Young's Hotel, Boston, April 19, 1882.

What is a water works superintendent? What are his duties and qualifications?

The answer to these questions must vary with the population and other conditions of the town or city where the office is located. The smaller the town, the smaller will be the superintendent's salary and the more manifold his duties. He may be obliged to run the pumps, collect the water-rates, lay pipes, keep records, be draftsman, foreman of laborers, steam engineer, civil engineer, and clerk all in one, with a salary not at all commensurate with the extent of his duties. If in a large city, his duty will consist mainly in directing, by due oversight, the work of a body of skilled subordinates in a thorough and efficient administration of the affairs of the water works under his charge.

With this preface, may it not be profitable for a few minutes to attempt to outline the qualifications of an ideal superintendent?

He must, first of all, be self-reliant, not self-conceited. The self-reliant

man knows his own powers and limitations. He will insist, in a dignified manner, upon proper deference and respect to his rightful authority, and inspire confidence in his own ability. At the same time, he will often seek advice from a competent source, and in emergencies and critical cases, while prompt to act, never be hasty, rash, or foolishly obstinate.

The self-conceited man overrates himself and underrates his fellows. He strives to carry out his pet plans, not because they have been carefully considered and are the best, but because they are his.

The superintendent, if able to have a corps of assistants, must know enough of the details of their duties and enough of human nature to be a judge of their fitness to perform the tasks assigned them. He should know how to "*size up*" a man, so as to decide whether, notwithstanding some faults and weak points, he is, on the whole, a success, or on the other hand, whether, although possessing ability and skill, he has some radical defect of character which unfits him for his place and calls for his discharge. The more the superintendent knows of mechanical and civil engineering, the better. He must, at least in a general way, be responsible for the care of much valuable machinery, and, in the growth of cities and towns, much construction work must fall to the lot of water works men. It is important that the superintendent have sufficient engineering skill to give weight to his opinions in regard to all water works construction.

Of even more importance is it that he should have a thorough knowledge of water. There are many experts in steam, civil, and mechanical engineering; many expert chemists and botanists. But the number of men who understand water, the conditions of its purity, the sources of its supply, the causes of contamination, the best methods of distribution, the changes which water undergoes under the varying circumstances of light, heat, soil, air, depth, and contaminating elements, and who, at the same time, can make their fellow-men believe they understand water, this number of men is, at present, small.

Whatever the sciences of geology, botany, chemistry, and bacteriology can teach in regard to the quality of water should be known to the superintendent. He must be a student, a reading man, of practical common-sense, of courage, patience, and perseverance.

Above all else he should be a gentleman, that by his bearing he may win the good will of the public whom he serves, for the highest ability is useless to one who cannot command the support of the community whose confidence is essential to his success. Who among us would claim to possess all the qualities I have described?

Yet, although no one of us reaches the standard here set forth, the New England Water Works Association as a body does possess the ideal superintendent. By our meetings, our JOURNAL, our discussions, our harmonious interchange of thought and experience, we are as one man, the ideas and powers of each welded together into one perfect whole, ready to meet any emergency and to carry forward any enterprise of water works maintenance or construction. At least, if such is not the present actual state of the case, such a condition is attainable from the character of the membership of the Association.

What we most need is to make the strength of which we are ourselves conscious become a living reality to the world at large.

The general public should understand that problems of water-supply which the

ordinary citizen is utterly incapable of solving and upon which his opinions are valueless, it is the business of the members of the New England Water Works Association to study and solve.

In other professions, like that of the teacher and the physician, he who does not belong to any organized body of his fellows is considered behind the times and non-progressive, and is likely to lose professional standing.

It should be understood that the New England water works official who has no connection with this Association, who does not read its JOURNAL, is behind the age and unfitted to administer the affairs of water works.

We should interest the public press to spread before the people more fully than has yet been done the work of this Association.

I have found intelligent citizens who did not even know of its existence.

A body of 412 members, embracing all shades and kinds of water works engineering experience, chemists, botanists, and other scientists, is competent to teach the people many valuable things about water-supplies, and if we may judge by the absurd statements sometimes seen in the daily press, there are few questions of which the common people are more ignorant than upon a question of a proper public water-supply. This shows the need of such societies as ours.

Brethren, if we continue to work together to enlarge our membership, increase our funds, add to our stock of knowledge, and thus increase our usefulness, we have before us as an organized body, a long and prosperous life. (Applause.)

The Secretary then read the following:

ANNUAL REPORT OF THE SECRETARY.

NEW ENGLAND WATER WORKS ASSOCIATION,
OFFICE OF THE SECRETARY,
NEW BEDFORD, MASS., June 1, 1893.

TO THE MEMBERS OF THE NEW ENGLAND WATER WORKS ASSOCIATION:

Gentlemen: Your Secretary herewith presents his report for the year ending May 31, 1893.

On June 1, 1892, the membership of this Association was as follows, viz.:

Active members	290
Honorary members	5
Associate members	70
Total	365

During the year there has been a loss of twenty-four members, from the following stated causes:

Resignations	16
Deceased	2
Suspended for non-payment of dues	4
Declined membership after election	2
	24

Seventy applications for membership have been presented, endorsed by the executive committee, all of which have received favorable action.

One application for reinstatement as an active member has been granted.

The membership at this date is

Active members	338
Honorary members	5
Associate members	69
Total	412

The net gain for the year has been 47 members.

It may be of interest to trace the growth of the Association from the date of its organization. The following statement shows the membership at the end of each Association year.

June 21, 1882	27
" 1, 1883	43
" " 1884	57
" " 1885	127
" " 1886	153
" " 1887	191
" " 1888	238
" " 1889	277
" " 1890	335
" " 1891	360
" " 1892	365
" " 1893	412

Your Secretary has made 530 collections, which may be thus itemized:

Advertisements	$1,400 00
Initiations	317 00
Dues	1,293 00
Sale of badges	86 95
Sale of journals	237 48
	$3,334 43

All of which has been paid to the Treasurer.

Respectfully submitted,

R. C. P. COGGESHALL,
Secretary.

The report was accepted.

Mr. Nevons, Treasurer, submitted the following report:

ANNUAL REPORT OF THE TREASURER.

HIRAM NEVONS, TREASURER, IN ACCOUNT WITH THE NEW ENGLAND WATER WORKS ASSOCIATION.

1892.		DR.	
June	Balance on hand		$1,806 42
	Amounts received from		
" 15	R. C. P. Coggeshall, Secretary		200 00
" 24	" " "		300 00
Nov. 23	" " "		1,300 00
1893.			
Mar. 17	" " "		1,000 00
June 3	" " "		534 43
" 14	Accrued interest to date, Cambridge Savings Bank		29 90
" "	Accrued interest to date, Cambridgeport Savings Bank		160 14
			$5,330 89

1892.		CR.	
June 14	By payment to	Hiram Nevons	$15 00
" "	" "	Hotel Hamilton	30 45
" 18	" "	C. L. Barker	113 25
" 24	" "	Bacon & Burpee	67 30
July 13	" "	Chas. H. Currier	12 60
" "	" "	T. P. Taylor	23 61
Sept. 8	" "	Matthews-Northup Co.	18 00
" 30	" "	Heliotype Printing Co.	16 00
" "	" "	L. C. Smith	2 25
" "	" "	W. H. Richards	86 12
Nov. 2	" "	Charles F. Irons	184 00
" 21	" "	Charles W. Jenks & Bro.	3 00
Dec. 12	" "	R. C. P. Coggeshall	250 00
" "	" "	" "	152 42
" "	" "	Mercury Publishing Co.	129 70
" 15	" "	J. R. Whipple & Co.	18 00
" "	" "	F. L. Pratt	15 00
" 19	" "	J. R. Whipple & Co.	3 00
" 20	" "	J. W. Black & Co.	7 60
" "	" "	Thomas P. Taylor	11 00
" 23	" "	W. H. Richards	99 21
1893.			
Jan. 13	" "	Day Publishing Co.	277 25
" "	" "	George E. Starr	5 50
" 18	" "	J. R. Whipple & Co.	16 00
" 22	" "	F. L. Pratt	15 00
	Amount carried forward,		$1,571 26

Amount brought forward,					$1,571 26
Feb.	13	By payment	to	Heliotype Printing Co.	18 93
"	"	"	"	" " "	158 25
"	"	"	"	M. N. Baker	5 00
"	"	"	"	J. R. Whipple & Co.	18 60
"	"	"	"	F. L. Pratt	15 00
"	18	"	"	H. C. Whitcomb & Co.	18 00
"	20	"	"	Carl J. Viets	1 30
"	24	"	"	Day Publishing Co.	208 04
"	"	"	"	Heliotype Printing Co.	67 50
Mar.	13	"	"	J. R. Whipple & Co.	19 50
"	"	"	"	F. L. Pratt	15 00
"	21	"	"	Heliotype Printing Co.	10 00
"	"	"	"	Bacon & Burpee	60 00
"	24	"	"	Heliotype Printing Co.	40 00
"	"	"	"	W. H. Richards	110 86
"	31	"	"	Heliotype Printing Co.	16 50
April	8	"	"	Day Publishing Co.	297 00
"	"	"	"	Heliotype Printing Co.	17 50
"	"	"	"	C. C. Taylor	6 00
June	6	"	"	R. C. P. Coggeshall	250 00
"	"	"	"	" "	105 42
"	"	"	"	Edwin Dews	9 00
"	"	"	"	Mercury Publishing Co.	175 00
"	7	"	"	J. W. Black & Co.	13 40
"	8	"	"	Forbes Lithograph Manufacturing Co.	43 68
"	"	"	"	" " " "	6 00
"	"	"	"	W. T. Almy	20 48
"	12	"	"	Hiram Nevons	20 00
					$3,317 22

"	14	Balance on hand National City Bank	$323 63
		Cambridge Savings Bank	500 00
		Accrued interest to date	29 90
		Cambridgeport Savings Bank	1,000 00
		Accrued interest to date	160 14
			2,013 67
			$5,330 89

Respectfully submitted,

HIRAM NEVONS, *Treasurer.*

Approved.

A. R. HATHAWAY,
JOHN L. HARRINGTON.

The report of the Treasurer was accepted.

The special committee, continued at last convention to consider the recommendations made by ex-President Noyes at the Hartford convention in regard to permanent headquarters, not being ready to report, the matter was passed.

Mr. FitzGerald, chairman of a special committee appointed to consider the question of "Uniformity in the Preparation of the Annual Report," submitted the following report in behalf of the committee:

REPORT OF COMMITTEE ON STATISTICS IN ANNUAL REPORTS.

At the Springfield convention of June, 1885, Messrs. Billings and Coggeshall, after an exhaustive study of the question of uniformity in annual reports, submitted recommendations as to a form of statistics and suggestions for a model report covering the management, construction, and finances of a water works system.

This excellent report has formed the basis for the tables adopted by many of the cities and towns, not only in New England, but throughout the United States.

All who have occasion to study the annual reports submitted by water boards and others must acknowledge that the information contained in the statistics is more often consulted than any other portions of these official documents. Their great value has been abundantly demonstrated by the eight years which have passed since Messrs. Billings and Coggeshall submitted their suggestions.

Your committee recently appointed to ascertain the best steps to take to secure a more general adoption of the "statistics" have given the subject much thought and have consulted many members of the Association.

All agree as to the desirability of a greater uniformity, and none have been able to suggest improvements in the forms already recommended.

Your committee have come to the conclusion that there is nothing of material value to be added to these forms as outlined in 1885, and that as the principal cities in New England have already largely adopted them, it would be unwise to change the statistics. Among the important municipalities which now use these forms, in whole or in part, are the following:

Boston,	Ware,	Plymouth,	Woonsocket,
Fall River,	Lynn,	Springfield,	New London,
Fitchburg,	New Bedford,	Taunton,	Burlington,
Holyoke,	Newton,	Waltham,	

and among those which have not yet adopted the statistics are the following places:

Brockton,	Hartford,	Meriden,	Salem,
Brookline,	Keene,	Natick,	Waterbury,
Cambridge,	Lawrence,	New Britain,	Whitman,
Clinton,	Lowell,	Pawtucket,	Woburn,
Concord, N.H.,	Malden,	Pittsfield,	Worcester.
Holbrook,	Melrose,	Providence,	

Your commitee recommend that a large edition of Messrs. Billings and Coggeshall's report be reprinted in full in pamphlet form, with covers and an

appropriate title, and that copies be sent to the water boards and other officials throughout the country, accompanied by a few words of earnest appeal in favor of a universal adoption of the forms recommended.

Respectfully submitted,

DESMOND FITZGERALD,
WILLARD KENT.

On motion of Mr. Brackett, the report was accepted and the matter referred to the executive committee with full powers to carry out the recommendations.

Mr. BRACKETT. This is a subject of sufficient importance to warrant further consideration. I feel a very deep interest in the more general adoption of this plan by the towns and cities of New England than has been heretofore. If all of our members could be impressed with the value of the tables, instead of only 18 cities and towns as now, we should have every member of the Association joining in a work which can be very easily carried out and would be of immense value. The larger the number that adopt the plan, the greater will be the value of the resulting tables. Much of the data included in the form suggested is now given in the different annual reports, but it is scattered about on different pages, and often given in such a way as to be unavailable for comparison with other reports. I think great credit is due to the members of the original committee for the thoroughness with which they did their work, so that after a trial of a number of years no changes are suggested by the committee which has now examined into the question.

In the last number of the JOURNAL you will find a compilation of the statistics of 18 cities and towns for the past 5 years. They will be found not only convenient for reference, but they are worthy a careful perusal.

In compiling these statistics a number of facts have been brought prominently to my attention. One is the large increase in consumption in many cities and towns during the past five years. For instance, the consumption in Burlington, Vt., has risen from 50 to 58 gallons per day for each consumer; Fitchburg, from 84 to 95; Lynn, 49 to 55; Newton, 31 to 49; Taunton, 37 to 46; Waltham, 32 to 47. Those are suggestive figures, and if this continues we must study to find a remedy. I trust that every member will, in the next annual report, follow out the suggestions of the committee and add the 2 or 3 pages giving the statistics in the form which they suggest, so that they can be tabulated and printed in our JOURNAL in a convenient form for reference.

There being no other business to come before the convention, the reading of papers was in order. The first paper was presented by John Thomson, Hydraulic Engineer, New York city, its title being, "Is the Game Worth the Candle?" under which he considered the question of whether it is wise to seek to attain exactness in construction and operation of meters. Mr. Walker and Mr. Brackett were called upon by the President to discuss the paper.

Mr. Nevons presented photographs and explained the operation of a little device of his invention for measuring the thickness of pipe, and the convention then adjourned till 7.30 P.M.

EVENING SESSION.

At the evening session, on motion of Mr. Nevons, seconded by Mr. Walker, the Secretary was directed to send the greetings of the Association to Mr. Hawes, of Fall River, and to express the regret of the members at his inability to be present.

W. E. McClintock, Civil Engineer, Boston, read a paper entitled "Water Pipe Trenches *vs.* Good Roads," illustrated by the stereopticon. Mr. Fuller, Mr. Nevons, Mr. Decker, and Mr. French spoke upon topics suggested by the paper.

Prof. Dwight Porter, of the Massachusetts Institute of Technology, gave a description, illustrated by the stereopticon, of the Hydraulic Laboratory at the Institute.

Adjourned to Thursday, at 9 A.M.

MORNING SESSION.

THURSDAY, June 15, 1893.

Mr. Holden, chairman of the Nominating Committee, made the following report:

OFFICERS, 1893-94.

PRESIDENT.

GEORGE E. BATCHELDER, Worcester, Mass.

VICE-PRESIDENTS.

JOSIAH S. MASEY, Gardner, Maine; CHARLES K. WALKER, Manchester, N.H.; F. H. CRANDALL, Burlington, Vt.; GEORGE A. STACY, Marlboro', Mass.; BYRON I. COOK, Woonsocket, R.I.; SHERMAN E. GRANNISS, New Haven, Conn.

SECRETARY.

R. C. P. COGGESHALL, New Bedford, Mass.

TREASURER.

HIRAM NEVONS, Cambridge, Mass.

SENIOR EDITOR.

DEXTER BRACKETT, Boston, Mass.

JUNIOR EDITOR.

WALTER H. RICHARDS, New London, Conn.

EXECUTIVE COMMITTEE.

F. F. FORBES, Brookline, Mass.; A. H. SALISBURY, Lawrence, Mass.; P. KIERAN, Fall River, Mass.

FINANCE COMMITTEE.

JNO. C. WHITNEY, Newton, Mass.; T. W. SAWYER, Milford, Mass.; JOHN L. HARRINGTON, Cambridge, Mass.

On motion of Mr. Fuller the report was accepted.

On motion of Mr. Eaton the Secretary was directed to cast the ballot of the Association for the nominees, and they were declared elected officers for the ensuing year.

No communication having been received as to the place where the next annual convention should be held, on motion of the Secretary the subject was referred to the executive committe with power.

Mr. John C. Chase, Engineer and Superintendent, Clarendon Water Co., Wilmington, N.C., presented a paper entitled "An Experience with a Standpipe."

The Secretary read a paper prepared by Mr. William R. Hill, Chief Engineer, Syracuse Water Works, Syracuse, N.Y., giving an account of "The location, construction, and laying of a 54-inch steel submerged-pipe in Skaneatles Lake, for the Syracuse Water Works."

Mr. Clemens Herschel gave a summary of his paper on "The Works of the East Jersey Water Company for the Supply of Newark, N.J.," calling attention to the special novel features of the work.

Professor Drown's paper on "Purification of Water by Freezing" was read by Mr. F. P. Stearns.

Mr. Brackett opened the discussion on the topic "Details of Pipe Castings and Coating," and was followed by Mr. Billings, Mr. Noyes, Mr. Allen, and Mr. Fuller. The topic "The Filling of Service Pipes by Sediment or Tuberculation" was discussed by the President, Mr. Noyes, Mr. Fuller, Mr. Brown, Mr. Beals, and Mr. Chase.

The Secretary read the following communication:

WORCESTER, June 14, 1893.

At a meeting of the associate members of the N. E. W. W. Association, Mr. Anthony Smith in the chair, the following resolution was offered and unanimously carried:

Resolved, That the associate members of the N. E. W. W. Association highly appreciating the liberal provision made by the Association of a hall and other conveniences for the display of Water Works supplies and accessories, are duly grateful for the courtesy extended, and hereby tender their most hearty thanks to the Association for the same.

Respectfully submitted,

W. D'H. WASHINGTON,
Secretary.

The convention then adjourned to 7.30 P.M.

EVENING SESSION.

At the evening session Mr. F. W. Dean, of Boston, made an address, illustrated by the stereopticon, on "Recent Practice in Pumping Machinery."

NEW MEMBERS ELECTED.

Joseph L. Kenney, Superintendent, Lewiston, Me., and Frank L. Northrup, Superintendent, Milford, Mass., were elected Resident Active Members.

On motion of Mr. Brackett, the Secretary was directed to extend the thanks of the Association to the city of Worcester, through the Water Department, to the Union Meter Company, and to others who may have, during the sessions, added to the pleasure of the meeting.

Adopted.

The Secretary put the motion that the thanks of the Association be given to the President for the able manner in which he had presided.

Adopted.

The PRESIDENT. I thank you, gentlemen, for your appreciation. I assure you it has been a very agreeable and pleasant duty to preside over your meetings the past year; and if there has been any success on my part it has certainly been due to the very cordial support I have received from the officers and other members of the Association. It now gives me pleasure to present to you the President for the ensuing year. I am sure you can be congratulated upon your choice. The office will be honored by the city of Worcester, by the Water Department of Worcester, and by the man. Gentlemen, I present to you your President, Mr. George E. Batchelder. (Applause.)

President Batchelder then took the chair and said:

Gentlemen of the New England Water Works Association: Accept my thanks for the honor you have conferred upon me to-day by electing me to this office. It certainly is an honor for any man to be chosen to preside over a representative body of men like this. My predecessors in office have set me the example of brevity in speech, which is fortunate for me. I do wish to say, however, that we had thought our plans were almost perfect for one of the best conventions ever held by the Association, but the unfortunate event occurring, over which we of course had no control, completely demoralized us. I know that many of you have been discomforted, and I am very sorry it should have happened so; but I am happy to say that all of you have taken it in good part. Again thanking you for your kindness, the Chair is ready for any motion.

On motion of Mr. Brackett, the convention adjourned.

The social features of the convention were as follows: On Wednesday evening the visiting ladies were tendered a reception by Mrs. George E. Batchelder. On Thursday afternoon, by invitation of the Worcester Water Department, the members and friends enjoyed a ride in barges to various points of interest about the city, including Institute and Elm parks, and an interesting inspection of the works of the Washburn & Mowen Manufacturing Company, the buildings of the Worcester Polytechnic Institute, the works for purification of sewage at Quinsigamond, and the Union Water Meter Company's works. At the latter place a

lunch was served. After returning to the City Hall a trial of eight fire streams from the high service hydrants was witnessed.

On Friday by the courtesy of the Union Water Meter Company, the members and ladies were entertained at Lake Quinsigamond, where several hours were pleasantly spent with games and trips around the Lake. The entertainment terminated with a lunch and clambake, and after remarks by Messrs. Walker and Stacy expressing the appreciation of the Association of the courtesy of the officers of the city and the Union Water Meter Company, which were pleasantly responded to by the Mayor, the party returned to the city.

LIST OF EXHIBITS BY ASSOCIATE MEMBERS AT THE CONVENTION.

Ashton Valve Company, Boston, Mass., Relief Valves.

Coffin Valve Company, Boston, Mass., Valves and Hydrants.

Crosby Steam Gage and Valve Company, Boston, Mass., Hose, Gages, Valves, etc.

Curtis Regulator Company, Boston, Mass., Pressure Regulators and Reducing Valves.

Deane Steam Pump Company, Holyoke, Mass., Photographs of Pumping Machinery.

The Fairbanks Company, Boston, Mass., Valves.

Frost & Adams, Boston, Mass., Draughtsmen's Materials.

Hersey Manufacturing Company, South Boston, Mass., Meters.

The Hydraulic Construction Company, New York city, Driven Well Apparatus.

Henry F. Jenks, Pawtucket, R.I., Drinking Fountains and Pipe Wrench.

H. W. Johns Manufacturing Company, Boston, Mass., Asbestos specialties.

Michigan Brass and Iron Works, Detroit, Mich., Hydrants.

National Meter Company, New York city, Meters.

National Tube Works Company, McKeesport, Pa., Enamelled and Kalamine Pipe.

Neptune Meter Company, New York city, Meters.

Perrin, Seamans, & Co., Boston, Mass., Construction Tools and Water Works Supplies.

George Ross, Troy, New York, Regulator and Reducing Valves.

Rensselaer Manufacturing Company, Troy, N.Y., Valves.

Anthony P. Smith, Newark, N.J., Tapping Machine.

B. C. Smith, New York city, Pipe Cutting Machine, Meter Connection, Curb Stop and Eel Guard.

Taunton Locomotive Manufacturing Company, Taunton, Mass., Lead Furnace and Stop Box.

Thompson Meter Company, Brooklyn, N.Y., Meters.

Union Water Meter Company, Worcester, Mass., Meters.

Walworth Manufacturing Company, Boston, Mass., Valves and Tools.

R. D. Wood & Co., Philadelphia, Pa., Hydrants, Valves, and Cutting in Special.

The George Woodman Company, Boston, Mass., Stop Cocks and Knuckle Joint Shut-off.

A. R. Worthington, New York city, Meters.

Weir Meter Company, Salem, Mass., Meters.

ATTENDANCE AT THE CONVENTION.

ACTIVE MEMBERS.

Everett L. Abbott, New York city.
Charles A. Allen, Worcester, Mass.
Frank A. Andrews, Nashua, N.H.
R. C. Bacot, Jr., Hoboken, N.J.
Charles H. Baldwin, Boston, Mass.
Lewis M. Bancroft, Reading, Mass.
George E. Batchelder, Worcester, Mass.
Joseph E. Beals, Middleboro', Mass.
William R. Billings, Taunton, Mass.
Dexter Brackett, Boston, Mass.
John G. Brady, Worcester, Mass.
Arthur W. F. Brown, Fitchburg, Mass.
James Burnie, Biddeford, Me.
George F. Chace, Taunton, Mass.
E. J. Chadbourne, Neponset, Mass.
Charles E. Chandler, Norwich, Conn.
John C. Chase, Wilmington, N.C.
William F. Codd, Nantucket, Mass.
R. C. P. Coggeshall, New Bedford, Mass.
H. W. Conant, Gardner, Mass.
Byron I. Cook, Woonsocket, R.I.
George K. Crandall, New London, Conn.
George E. Crowell, Brattleboro', Vt.
Edwin Darling, Pawtucket, R.I.
Francis W. Dean, Boston, Mass.
J. H. Decker, New York city.
Nathaniel Dennett, Somerville, Mass.
Charles R. Dyer, Portland, Me.
Eben R. Dyer, Portland, Me.
Horace L. Eaton, Somerville, Mass.
Desmond FitzGerald, Brookline, Mass.
William F. Foss, Brighton, Mass.
D. W. French, Weehawken, N.J.
Albert S. Glover, Boston, Mass.
A. B. Goodier, Southbridge, Mass.
Frank E. Hall, Quincy, Mass.
A. R. Hathaway, Springfield, Mass.
Ansel G. Hayes, Middleboro', Mass.
Clemens Herschel, New York city.
James H. Higgins, Providence, R.I.
Horace G. Holden, Nashua, N.H.
David B. Kempton, New Bedford, Mass.
Joseph L. Kenney, Lewiston, Me.
E. W. Kent, Woonsocket, R.I.
Willard Kent, Woonsocket, R.I.
George A. Kimball, Boston, Mass.
Horace Kingman, Brockton, Mass.
Wilbur F. Learned, Watertown, Mass.
Joseph A. Lockwood, Yonkers, N.Y.
Thomas W. Mann, Holyoke, Mass.
W. E. McClintock, Boston, Mass.
William McNally, Marlboro', Mass.
George L. Mirick, Everett, Mass.
James W. Morse, Natick, Mass.
Hiram Nevons, Cambridge, Mass.
Edward C. Nichols, Reading, Mass.
Frank L. Northrop, Milford, Mass.
Albert F. Noyes, West Newton, Mass.
A. G. Pease, Spencer, Mass.
John F. Philbin, Clinton, Mass.
Edward H. Phipps, New Haven, Conn.
Dwight Porter, Boston, Mass.
Waldo E. Rawson, Uxbridge, Mass.
George S. Rice, Boston, Mass.
Walter H. Richards, New London, Conn.
George J. Ries, Weymouth Centre, Mass.
Daniel Russell, Everett, Mass.
Arthur F. Salmon, Lowell, Mass.
F. J. Shepard, Derry, N.H.
John D. Shippee, Holliston, Mass.
Solon F. Smith, Grafton, Mass.
George A. Stacy, Marlboro', Mass.
Frederick P. Stearns, Boston, Mass.
J. C. Sullivan, Holyoke, Mass.

Joseph G. Tenney, Leominster, Mass.
Robert J. Thomas, Lowell, Mass.
John Thomson, New York city.
Charles K. Walker, Manchester, N.H.
W. P. Whittemore, North Attleboro', Mass.
Frederick I. Winslow, Boston, Mass.
George E. Winslow, Waltham, Mass.
S. J. Winslow, Pittsfield, N.H.
Timothy Woodruff, Bridgeton, N.J.
Richard R. Yates, Northboro,' Mass.

HONORARY MEMBERS.

George H. Frost, New York city.
F. W. Shepperd, New York city.

ASSOCIATE MEMBERS.

J. L. Blaisdell, H. W. Johns Manufacturing Co., Boston, Mass.
James M. Betton, H. R. Worthington, New York city.
Albert A. Blossom, Hersey Manufacturing Co., Boston, Mass.
Harold L. Bond, Perrin, Seamans, & Co., Boston, Mass.
John F. Browning, Fairbanks Co., Boston, Mass.
George H. Carr, Union Water Meter Co., Worcester, Mass.
C. H. Eberle, Crosby Steam Gage and Valve Co., Boston, Mass.
J. H. Eustis, Walworth Manufacturing Co., Boston, Mass.
George B. Ferguson, H. R. Worthington, New York city.
J. A. Garrett, National Tube Works Co., Boston, Mass.
Jesse Garrett, R. D. Wood & Co., Boston, Mass.
S. D. Higley, Thomson Meter Co., Brooklyn, N.Y.
E. T. Ivins, Thompson Meter Co., Brooklyn, N.Y.
John C. Kelley, National Meter Co., New York city.
H. H. Kinsey, Rensselaer Manufacturing Co., Troy, N.Y.
J. G. Lufkin, National Meter Co., Boston, Mass.
Charles Lynch, Michigan Brass and Iron Works, Detroit, Mich.
Hugh McCarron, Dean Steam Pump Co., Boston, Mass.
William B. Meldon, Thomson Meter Co., Brooklyn, N.Y.
W. H. Moulton, Union Water Meter Co., Worcester, Mass.
J. P. K. Otis, Union Water Meter Co., Worcester, Mass.
A. M. Pierce, Dean Steam Pump Co., Boston, Mass.
B. Frank Polsey, Walworth Manufacturing Co., Boston, Mass.
George Ross, Ross Valve Co., Troy, N.Y.
Anthony P. Smith, Newark, N.J.
Benjamin C. Smith, New York city.
F. P. Smith, Curtis Regulator Co., Boston, Mass.
W. F. Spear, The George Woodman Co., Boston, Mass.
F. E. Stevens, Peet Valve Co., Boston, Mass.
Usher B. Thompson, Weir Meter Co., Salem, Mass.
W. H. Van Winkle, A. P. Smith, Newark, N.J.
William D'H. Washington, The Hydraulic Construction Co., New York city.
E. J. White, Frost and Adams, Boston, Mass.

GUESTS.

J. P. Bacon, Boston, Mass.
M. N. Baker, *Engineering News*, New York city.
George W. Barrett, Registrar, Malden, Mass.
Mrs. Jos. E. Beals, Middleboro', Mass.
W. L. Beals, Civil Engineer, New Britain, Conn.
Mrs. Dexter Brackett, Boston, Mass.
Thos. Burke, Water Committee, Marlboro', Mass.
Patrick Byrne, Foreman, Marlboro', Mass.
Mrs. William F. Codd, Nantucket, Mass.
Mrs. R. C. P. Coggeshall, New Bedford, Mass.
James W. Cassidy, Water Board, Lowell, Mass.
William D. Doyle, Marlboro', Mass.
H. P. Eddy, Supt. Sewers, Worcester, Mass.
Mrs. J. H. Eustis, Boston, Mass.
John Garvey, Worcester, Mass.
David A. Hartwell, City Engineer, Fitchburg, Mass.
W. C. Jewett, Water Committee, Worcester, Mass.
J. N. Jordan, Supt., Malden, Mass.
Mrs. David B. Kempton, New Bedford, Mass.
Henry A. Marsh, Mayor, Worcester, Mass.
L. D. May, Chicago, Ill.
Mrs. L. D. May, Chicago, Ill.
W. E. Mayberry, Supt., Braintree, Mass.
Peter Milne, *Fire and Water*, New York city.
George D. Moore, Instructor, Worcester, Mass.
P. B. Murphy, Marlboro', Mass.
Mrs. A. G. Pease, Spencer, Mass.
R. Pattee, Hartford, Conn.
R. M. Pratt, *Daily Enterprise*, Marlboro', Mass.
Geo. M. Rice, 2d, Water Committee, Worcester, Mass.
Mrs. Daniel Russell, Everett, Mass.
Mrs. Arthur F. Salmon, Lowell, Mass.
John V. Scolland, Registrar, Braintree, Mass.
Stephen H. Taylor, New Bedford, Mass.
Chas. J. Underwood, *Engineering Record*, Boston, Mass.
Jas. H. Wheeler, jr., West Newton, Mass.
Warren B. Wheeler, Asst. Engineer, Fitchburg, Mass.
H. A. Wilder, Auditor, Malden, Mass.
John Winn, Asst. Foreman, Marlboro', Mass.

THE WORKS OF THE EAST JERSEY WATER COMPANY, FOR THE SUPPLY OF NEWARK, NEW JERSEY.

By

Clemens Herschel, Hydraulic Engineer, New York.

September 24, 1889, was signed a tripartite agreement between the Lehigh Valley Railroad Company, the East Jersey Water Company, and the City of Newark, New Jersey, of a somewhat novel form and tenor. Briefly stated, the Railroad Company, which by virtue of rights in the old Morris Canal controlled water rights that could be made useful towards the supply of water for domestic purposes to the city and elsewhere, became the sponsor and warrantor of the Water Company; the Water Company undertook to build works for the supply of Newark with pure and wholesome water, to the amount of 50 million gallons daily (77.35 cubic feet per second); the supply to the city up to, but not exceeding, 27½ million gallons daily, if so much be needed by the city, to commence May 1, 1892; the Water Company to have the right to draw from the conduit all that the city did not draw, until Sept. 24, 1900, and to control, maintain, and be responsible for the works to that time; the city agreeing to pay four (4) millions of dollars May 1, 1892, and two (2) millions of dollars additional on Sept. 24, 1900, when the complete 50 million gallons works were to be handed over to the city for its sole use and control. It will be noticed that the agreement partakes largely of the nature of a copartnership for 11 years. It enables the city to profit by the superior economy inherent in the purchase of rights and construction of works by a private company; while not exposing its citizens to such annoyance and oppression as may be incidental to a house-to-house collection of water rates by a private corporation. It is not intended here to discuss the mooted question of the relative merits of private or of public ownership for water works, only to point out the precise standing in this discussion, if it belong there, of the case in hand.

A parallel case is the contract by which the city of Philadelphia, owning and administering its gas works, yet contracts with a private gas company to deliver into its gas-holders gas by the million cubic feet. And apart from these two cases, the writer is not acquainted with similar contracts.

It will have been observed that only two working seasons, in all 2 years and 7 months, were allowed the Water Company in which to build the works. This short time will seem still shorter when it is considered that, beyond reconnoissances in the country whence the supply was to come, no surveys, still less designs of works to be built, had been made at date of signing the contract. The contract itself gives proof of the situation in this respect, in defining that the waters to be supplied are to be derived "from the Pequannock, Wynockie, or Ramapo water-sheds," being the Indian names of three tributaries of the Passaic river, in the State of New Jersey; of these three, the Pequannock (meaning, Black Water) became the decided favorite with the city authorities during the negotiations, and for this reason, among others, was the source finally selected by the Water Company. So that at time of signing the contract, this

much uncertainty had been practically eliminated from the undertaking, and there remained merely to build the required works from the Pequannock watershed to the city of Newark in 2 years and 7 months. As the new supply to the city of Newark has been in operation since April 26, 1892, it will be seen that this contract time was complied with; but it is necessary, for a proper understanding of the works about to be described, to remember that preliminary surveys, location, and construction proceeded simultaneously from the outset. Very great aid was derived in the early stages of the work from the excellent topographical or contour maps of the State of New Jersey; a piece of cartography no doubt destined to be of lasting renown to the State, and to its chief, the late Prof. George H. Cook.

At later stages of the work, the facilities for the making of large contracts afforded by the possession of ample monetary resources, and the influence and information possessed by the officers of the Lehigh Valley Railroad Company, became important factors in hastening the work.

While laying no claims to great elegance or monumentality of design, yet as a presentation of what modern facilities of construction can accomplish within a limited time, the works are believed to constitute an interesting exhibit. Some novel features of hydraulic construction embodied in them may also prove of interest to the ever-advancing profession of the civil and hydraulic engineer.

GENERAL DESCRIPTION.

The works consist in the main of two storage reservoirs: Oak Ridge, 383 acres of water surface, and Clinton, 423 acres of water surface, which discharge through the ancient and natural river and brook channels, 9 miles and 7 miles long, respectively, into the Macopin Intake Reservoir, 12 acres of water surface. Here commences the 48-inch steel conduit, 21 miles long, which carries the water to Belleville Reservoir, a low-service distribution reservoir of the city of Newark; thence branching from the main conduit is a steel pipe, 36 inches in diameter and 5 miles long, which leads to the South Orange-avenue Reservoir, a high-service city distribution reservoir.

In profile, we have Clinton wasteway on elevation 992 feet above mean level of the sea; Oak Ridge wasteway on elevation 836; Macopin Intake Dam on elevation 583.7; the hydraulic gradient of the conduit falling 2 feet per 1,000, and reaching Belleville Reservoir at elevation 358, while full water in Belleville Reservoir is on elevation 168.4; finally, the hydraulic gradient reaching South Orange-avenue Reservoir at elevation 300, in accordance with the terms of the contract, while full water in this reservoir is on elevation 226.6, though that of a new distributing reservoir, proposed to be built by the city, and to serve what is now called the "Special High Service," may be on elevation 300.

There is thus given 408 feet fall, on a distance of 7 miles of a mountain brook, for the water issuing from the Clinton Reservoir, and 252 feet fall, on a distance of 9 miles of a rocky river, for the water issuing from Oak Ridge Reservoir, in which to be aerated, in flowing down to the Intake. And the unusual amount of fall from the Intake to the points of delivery was utilized in generating velocity; that is, in reducing the diameter of the main conduit. As it has from the outset been intended by the East Jersey Water Company to supply out of the main

conduit and out of its water right of 22½ million gallons, or more, other cities and towns along the route, until Sept. 24, 1900 (thereafter from works to be built in the meantime), the waste of head or pressure at Belleville Reservoir is not without compensating advantages. The greater the head at Belleville, the wider the range of possible future water customers for the company. And after 1900, when the whole works will have passed to the city, the excess of pressure at Belleville may be utilized by the city, if desired, to produce a respectable amount of power; hence, in these days of power transmission, of income.

Oak Ridge Reservoir. — The reservoir at Oak Ridge has a drainage area appurtenant to it of 27.3 square miles; its water surface, as stated, is 383 acres; cubic contents, 2,555 million gallons; from high-water mark, on elevation 836, to the bottom of the outlet pipes is 44.5 feet. The dam forming it is an earth dam, of cross-section as shown on the drawings, being a straight dam, 40 odd feet high, slopes 2 to 1 on both sides, with a berme half-way up on each side, 16 and 10 feet wide respectively, on the water and on the down-stream side.

It has been argued that the same material that is required to make bermes on high earth-dams, if placed in form of a flatter slope on the dam, would be more effective to prevent slip, and for other purposes. The author is, however, of the opinion that bermes are fully justified in the case of high dams, by the convenience they afford as level roadways from one side of the valley to the other, more especially during construction.

A core-wall of concrete extends from the ledge, some 28 feet below the original meadow surface, to the level of the full water-line of the reservoir. It is 8 feet thick at the level of the original meadow surface, and tapers to 5 feet thick at the top. It also tapers downward, following the lines of the sheet-piling, driven to support the sides of the trench. So far, the dam follows ordinary forms of construction. Its one peculiarity is a covering of small boulder-stone, some 3 feet thick, on the down-stream side, instead of the grass-surface usually cultivated on that side at a great expense of patient renewals after every rain. The reason for this was the excessive amount of stone found in getting the gravel with which to build the dam, which had to be culled out of the material to be dumped and rolled, but which had to be disposed of, nevertheless, somewhere. Their use, for the purpose named, has proved entirely satisfactory, and the author is prepared to recommend a repetition of this form of covering for the down-stream side of reservoir dams. It answers every constructive demand, and, as no one has ever, to the author's knowledge, said aught against the appearance of this slope-covering, while many have said that it gave the dams a look of great stability, it may fairly be claimed that æsthetic considerations, also, have been fully met by this covering of small boulders. On the water-side, a covering of the larger boulder-stone found in the gravel-pits was laid up as the dam was built, with gravel washed into the crevices.

The outlet channel of the reservoir is a cut blasted through the ledge around one end of the dam, this being done to avoid placing the gate-house in the body of the dam. In this channel is built a simple form of gate-house, consisting of two dry wells, in which to reach the four gates controlling the four outlet pipes. These latter are 42 inches in diameter, tapering to connect with 30-in. gates at

the centre, then gradually expanding again to 42 inches in diameter. A simple form of flap-gate can be lowered to close the up-stream end of each pipe, for the possible event of the 30-in. gate on that pipe needing repairs. By setting a 30-in. gate in line of a 42-in. pipe in the manner indicated, a material saving of expense is effected, without materially diminishing the capacity of discharge from what it would be with 42-in. gates, in line of the same size pipes. Experiments made on the discharge of one of these gate-house pipes will be given later.

The gate-house is roofed with iron beams and the ordinary cast-iron and glass city sidewalk covering, which lights and warms the interior of the dry wells in a very satisfactory manner. An iron railing completes the structure.

The wasteway is merely the top of a hill of ledge cut down to a uniform level, on a length of 350 feet, and discharging into the outlet channel.

The top of the dam is on elevation 842.5, or 6.5 feet above the crest of the wasteway, or 4 feet above extreme high-water mark, with 2.5 feet depth of water wasting; which would allow for 160 cubic feet per second per square mile, as the discharge during extreme floods.

Clinton Reservoir. — Clinton Reservoir has a drainage area appurtenant to it of 9.5 square miles; its water surface is 423 acres; cubic contents, 3,518 million gallons; from high-water mark, on elevation 992, to the bottom of the outlet pipe is 41.3 feet.

In cross-section, and generally, in method of construction, this dam and its gate-house are like the Oak Ridge Dam which has just been described. In ground plan, this dam is curved, being convex up stream, though it is needless to say in this place that this was done to take advantage of the natural topography for the purpose of reducing volume of dam, and not from any idea of securing strength with a minimum of volume, by virtue of such curved outline in plan. The gate-house also is somewhat different from the Oak Ridge Gate-house, in being in a rock-cut only at the bottom, this rock-cut arched over, and the dam built on either side of, and surrounding, the gate-house. A dependence on this rock-cut to hold water proved ill-founded, and the leakage through the rock-seams had to be stopped in 1892, by a layer of concrete on the floor of the ledge channel, and lining its sides with brick and cement masonry. The wasteway is partly in excavation, partly in low embankment, at one extreme end of the dam, and consists merely of the concrete core-wall, capped with stone, and having embankments on either side, of boulder stone, laid on a slope of 4 :1, the interstices filled with gravel well washed in. Being so long, 300 feet for only 9.5 square miles of water-shed, the water can never run more than 1.5 feet deep, or at the rate of 180 cubic feet per second per square mile. For this reason, also, the top of Clinton Dam is only 5.5 feet above the crest of the wasteway, while it is 6.5 feet above the crest of the wasteway at Oak Ridge.

Macopin Intake. — The object of this dam is merely to form a small reservoir from which to take the water to be conveyed to the city into the conduit. This reservoir has a drainage area, especially appurtenant to it, of 25.9 square miles; making, with the Oak Ridge and the Clinton areas, 62.6 square miles appurtenant to the entire works; its water surface is 12 acres; cubic contents, 32 million gallons; from the crest of the dam, on elevation 583.7, to the bottom of the outlet pipes is 14.4 feet; but the hydraulic gradient of the conduit commences at elevation 579.2, or 4.5 feet below the crest of the dam.

The dam is a masonry structure, whose construction is sufficiently shown in the drawings. A novel feature is its location, being almost parallel with the original course of the Pequannock river. This line, and its curve, convex upstream, was chosen on account of a ledge of rock of the described situation, on which to place the overflow dam or waste-weir; a wing approximately at right angles to the same, the top on elevation 590.7 so as to be beyond the fear of overflow, forming the rest of the water-retaining masonry. The wasteway is 250.4 feet long, so that allowing at the rate of 140 cubic feet per second per square mile, as the measure of extreme freshets, not over five feet in depth may be expected ever to flow over this weir; which will leave the water level two feet below the high part of the dam, and the foundation ledge gives ample security against possible undermining.

The gate-house is a simple structure, shown in the drawings, and serving to suitably connect the reservoir with the conduit. It is provided with three sets of screens; four regulating sluice-gates, to control the flow of water from the screening-chamber to the conduit chambers; and a cross-connection gate, by means of which the two separate conduit chambers may be connected. The southerly conduit chamber has no conduit leading from it at the present time, and is now used only as a sluice wasteway. Should a second conduit be built in the future, sluice wasteways may be formed by branches leading from the two conduits, close to the gate-house.

CONDUIT.

General Description. — No doubt the most novel part of the whole work is the 48-inch steel conduit; a riveted boiler shell 21 miles long.

Such riveted pipes have been common in California for the past thirty years, and have been made of all sizes from 10 inches up to 44 inches in diameter. They are described in De Bow's "Hydraulic Mining," and in papers by Hamilton Smith, Jr., M. Am. Soc. C.E., in the Transactions of the American Society of Civil Engineers, 1883 and 1884. Also in "Hydraulics," by Hamilton Smith, Jr., 1886, Trübner & Co., London.

The City of Rochester, New York, built a riveted conduit 36 inches and 24 inches in diameter, in 1874, but this conduit has cast-iron bell and spigot joints every 56 feet. This obviates the necessity of manholes, and avoids raising the question of expansion joints; so that the Rochester conduit is not a true riveted conduit of the California type. The conduit of the East Jersey Water Company is, on the other hand, distinctly of that type, and is, besides, larger in diameter than any hitherto built in California, or anywhere else, of any great length, so far as known to the author.

One of the most startling features about these conduits is the entire absence of any mechanical contrivances to take up expansion and contraction. The story goes that an engineer from the Atlantic coast, in reporting on what he had seen in California, described these riveted pipes, and added the criticism that those Californians didn't even know enough to provide expansion joints; "and, would you believe it," he added, "they found out that they didn't need any." Be the authenticity of this anecdote as it may, there was, prior to the construction of the works of the East Jersey Water Company, no precedent for such

omission of mechanical contrivances to take up expansion and contraction, outside of California, so far as the author knows. And those who have been placed in like positions will appreciate the weight of responsibility which had to be borne in deciding upon the course adopted, when the success of a $6,000,000 contract depended on such decision, and there was no time to make especial experiments. The author made a journey to California principally to study this question on the ground; various designs of expansion joints, and of bell and spigot, and other forms of semi-expansion joint, or of joints made otherwise than by riveting, were also studied; with the result that, to the author, the promise of success was distinctly greater from the use of riveted joints than from any of the other kinds of pipe joint. And it may as well be stated right here that three winters' experience has shown no defect that can be traced to a lack of any mechanical appliance to take up expansion and contraction. The first winter the pipe was empty, and thermometrical records show that the temperature went slightly below 32° F. on several occasions. The second winter much worse than this took place, and worse than is ever likely to happen again. The pipe line being completed December 31, the rest of the winter was spent in testing the pipe, and remedying defects thus discovered; an operation that involved a repeated filling and emptying of the pipe. This was done during the best available weather, but in spite of all care taken, the pipe must frequently have been filled with air of a temperature below 32° F., then filled again with water of 32° temperature; portions of it stood empty, or with still water in them, during severely cold weather; and so on. No effect has ever been observed as resulting from this treatment of the pipe line.

The phrase "mechanical appliance" has been used advisedly, for there is, of course, an adjustment of the forces produced in the body of the conduit by changes of temperature, though it is not brought about by any mechanical detail. This adjustment is self-acting, and is a compound of the friction of the pipe in the ground and of the elasticity of the metal forming the conduit. Computation will not reveal all the details of this action, but if, as may readily be done, the circular joints are made strong enough to safely resist the tensile strains that would be produced in the conduit supposing it anchored down at the two ends during a variation of 45° F. (32°—77°), no trouble need be apprehended from expansion and contraction, as has been demonstrated in actual practice. Needless to say, that this plan once adopted, it must be followed out consistently, along the whole length of the conduit. Thus all stop-gates set in line of the conduit must have flanges and bodies sufficiently strong to resist the tensile strain produced in the conduit under the assumed variation of temperature of 45° F. The proper rule to follow the author believes to be, to make such places excessively strong, so that the weakest points in the line shall be in the conduit itself, and not in any of its appurtenances; and an examination of some of the detail drawings will show this rule to have been followed; with the satisfactory results above noted.

Once rid of the expansion-joint bugbear, the comparison between riveted pipe and cast-iron pipe can readily be made in specific cases, as they arise. present was a case in which a high velocity in the pipe was desirable, as a matter of economy; there was plenty of fall available, and a proper use of it would cause it to generate velocity; or, what is the same thing, diminish diameter.

The line followed gave 340 feet head on the pipe; and those two elements combined gave 6 feet velocity in a 4-foot pipe, under 340 feet head. These are measures which, if they do not positively exclude cast-iron, yet raise grave questions as to the practicability of cast-iron to meet them. Another objection to cast-iron was the length of time that would be required to cast 21 miles of 4-foot pipe, with all the foundries of large pipe in the country at work at it; or to lay it after it was furnished. And finally, an estimate of cost was largely in favor of the riveted pipe, even excluding the idea of a combination of pipe foundries to fix prices as they might want them.

Against the advantages of more trustworthiness, less cost, and less time required to construct, could only be put the fact that a steel pipe will float, and will collapse, under circumstances which do not similarly affect a cast-iron pipe; whence the necessity of guarding against such mishaps in the case of the riveted pipe by the proper designs and appliances. The question of durability was also raised, though the experience of the California lines of pipe for 20 years and over, that of the Rochester pipe for 18 years, and that of iron penstocks for water-power in the New England States for periods of 30 and of 40 years in single cases, is entirely satisfactory on the score of durability. The author has himself examined a length of some 200 feet of the Rochester pipe after it had been buried 18 years; also some photographs of the inside surface of two 20-inch discs cut from the same pipe, and is well acquainted with the appearance, inside and out, of New England penstocks of all ages, and can testify to the appearance, entirely free from rust, of the Rochester pipe, inside and out, and that the first case of a failure from rust of an iron penstock is yet to be heard from. It is true that the conduit of the East Jersey Water Company is of steel, while the principal experience had has been with wrought-iron. The preservative element is, however, the same in each case, being asphalt; and there is, over and above this, no reason to suppose that the superior metal will present any less resistance to corrosion than has wrought-iron. As will presently be seen in describing methods of manufacture, great care was taken to turn out a conduit which should be as securely protected from corrosion as could practically be accomplished.

While on the subject of choice of pipe, it should be stated that inquiries were extensively made as to the state of the art of tube-making, and whether any form of welded, or of seamless drawn, or of tube built up by processes other than by riveting, could be purchased, of desired quality, quantity, at an advantageous price, and within the desired time. While many such tubes were apparently on the point of being put on the market at advantageous rates, and some presumably will be at no distant day, no pipe was available in 1889 and 1890 which could compete with riveted steel pipe.

A novel feature of the pipe line is the fact that it has been designed and proportioned to resist, and is being operated to encounter, the pressures due to the hydraulic gradient only; in contra-distinction to those which would be produced by a hydrostatic head. This idea, while so far as known here first embodied in a finished pipe-line, had been previously suggested, as it now appears. Col. Geo. H. Mendell, Corps of Engineers, United States Army, proposed such a conduit for the city of San Francisco, in 1877; and Mr. Emil Kuichling, M. American Society Civil Engineers, now Chief Engineer of the Rochester

Water Works, who was Assistant Engineer in the construction of the Rochester Water Works in 1874, and again of the works of the East Jersey Water Company in 1889-90, independently hit upon the same idea. To carry it out in practice, it is only necessary to regulate the quantity flowing through the conduit by a sluice-gate placed at the up-stream end thereof, instead of by such a gate placed, as is usually done, at its down-stream end. In the case of open canals for irrigation, or for water-power purposes, this has been the method of regulation since such works were first constructed, and it may have been merely the author's many years' training on water-power canals that led him naturally to think of like methods for a closed conduit.

That such an arrangement is well worth striving for will appear from the fact that in case of the works of the East Jersey Water Company, this simple change effected a saving of fully 40 % in the weight, that is, in the cost of the manufactured conduit. At the present day, when a telephone has become one of the ordinary accompaniments of civilized life, there is no longer any excuse for building conduits any other way; so readily is the amount of water required in the distributing reservoirs controlled by the gate-keeper at the intake, in accordance with orders received by telephone. Finally, should the telephone line temporarily fail, the only harm that could occur would be a waste, at the distributing reservoirs, of the excess of water sent down; for which purpose waste-ways are provided; and to insure their being always open, no means are provided for closing them.

The telephone, be it said in passing, played as important a part in the construction of these works as it now does in their operation. The East Jersey Water Company built a telephone line of its own along the pipe-line, and to the several reservoirs. One instrument, called the "Perambulator," was moved along, from time to time, keeping pace with the progress of the work. Two portable instruments, with a pair of "climbers," formed, and still form, part of the outfit of the engineer corps, and can be put in circuit anywhere on the line in a minute or two. The author has frequently sat down on the ground in some field or piece of woods along the line, called up his office in New York, had the stenographer read him his morning's mail, dictated the replies thereto, called up other parts of the work, or called up two or three foremen on the line for a simultaneous consultation by wire; they and the engineer corps habitually did the same thing, so that it can readily be seen how the telephone contributed no little to the speed with which the whole work, stretched over 35 miles in length of territory, could be carried on. For the filling or emptying of the conduit, and generally for the conduct of hydraulic operations on the pipe-line, the telephone has shown itself — it is none too strong a term to use — invaluable. It may be credited with having caused a distinct advance in the possibilities of practical hydraulics.

We have then, as adopted, a riveted steel pipe, 4 feet in diameter, from Macopin Intake to the Belleville Reservoir, on a slope of 2 : 1,000, and a 36-inch pipe of this make, to branch from the 48-inch conduit near Belleville and extend to the South Orange-avenue Reservoir. There remains to speak of the appurtenances of the pipe-line, and of the process of manufacturing, and of laying the pipe.

PIPE-LINE APPURTENANCES.

Bridges. — In two cases is a river-crossing made on a bridge. The Pompton river and the canal immediately adjoining it are crossed by a four-span, ordinary wrought-iron truss-bridge, with the pipe hung on straps from the top chord. The Passaic river is crossed by a similar three-span bridge. All other brook and river crossings are either made by having the pipe support itself on spans not exceeding 10 feet, or by passing under.

Shut-off Gates and Interlocked Blow-off Valves. — There are on line of the 48-inch conduit nine 48-inch shut-off valves or gates, and two shut-off valves on line of the 36-inch pipe, besides the five 16-inch gates at the manifold to shut off the 36-inch pipe-line from the 48-inch conduit, at the junction of the two. These 48-inch valves are vertical valves with two 10-inch bye-passes, and are enclosed in little brick houses, forming at the same time tool-houses and depots of supplies along the line. The architecture of these gate-houses, and that of the very pleasing reservoir gate-houses mentioned later, is the work of Mr. Reuben Shirreffs, member of this Association.

The 36-inch valves are horizontal valves with 10-inch bye-passes, and are enclosed in underground vaults. In each case, excepting the two 48-inch valves furthest up-stream, the valve gear is so interlocked with the gear of an appurtenant blow-off valve that the shut-off valve cannot be closed until the blow-off valve has first been opened; and the blow-off valve cannot be shut again until the shut-off valve has again been opened. This is the arrangement adopted to prevent the possibility of an inadvertent closing of the shut-off gates while the water is running, or a turning on of the water while they are closed, the blow-offs being supposed shut in both cases; in either of which contingencies an excess of pressure would come upon the pipe up-stream from the shut-off gate in question. As regards the first gate above noted as an exception to the rule, it is located at a point such that the conduit up-stream from it can withstand the static head; and as regards the next gate down-stream from this, being the one at the foot of Pompton Notch, it is not interlocked with a blow-off, because there is an open overflow pipe on the hydraulic gradient in the Pompton Notch which would relieve the conduit from any excess of pressure caused by any possible handling of the gate at the foot of Pompton Notch. A study and test of relief valves such as ordinarily made and in the market, also of designs for such appliances by competent engineers, was conclusive in showing their excessive cost and the risk of depending on such for the discharge of a possible seventy-seven cubic feet per second. Such relief valves are mostly held down by springs, and the water pressure to open them is an entirely different and a greater one, so long as they are yet shut, than the pressure which obtains to keep them open after they have once begun to discharge water; and to make the matter worse, the action of the spring tending to hold them shut becomes stronger as they are lifted, so that none of them open very far or discharge any proper quantity of water at times when a copious discharge is needed, or is theoretically to be expected. Dead weights on the valves have the same and still other objections. Besides this, it must be remembered that relief valves in such a position would be expected to stand ready to operate for twenty years or more without deterioration, and yet be expected to fail not properly to act at the precise moment.

From all of which considerations it is submitted that the interlocking blow-offs adopted were the preferable apparatus.

It is proper to state in this connection that these 48-in., 36-in., and interlocking blow-off valves, and gear thereto appurtenant, were furnished by the Eddy Valve Company, of Waterford, N.Y., and that they have given entire satisfaction to date.

Pressure Regulators. — At the two terminal chambers, or reservoir gate-houses, however, it was necessary to set relief valves or pressure regulators, although these pressure regulators at the reservoirs will become superfluous when the city of Newark will have completed its new special high-service distributing reservoir. This simple but excellent apparatus was made by the Ross Valve Company, of Troy, N.Y., and is shown in the drawings. The operating part is the small relief valve I, set at the required pressure by the hand-wheel H. When this valve opens, an excess of pressure is formed in the chamber K, which depresses the main valve M, thus relieving the pressure that caused I to open. As a matter of safety, the piping and relief valve I is made in duplicate. As there are three pressure regulators in the Belleville Gate-house, each of which is governed by two independent relief-valves, there is a large measure of certainty of operation always at hand. Besides having the regulators set either in a locked-up gate-house, or else placed in charge of a keeper, the hand-wheels are taken off of all the valves, and the appurtenant shut-off valves are all made with indicators, to show whether they are open or shut; these and a proper supply of recording and alarm and ordinary pressure-gauges being precautions against an improper or unauthorized handling of the apparatus.

The positively best arrangement would be to have a separate conduit for the high and for the low service; to have no means of shutting off the water, whether automatically, as in pressure regulators, or by shut-off gates within the terminal gate-houses; that is, to have the down-stream end of the conduits always, and of necessity, wide open; and to have a reservoir at the desired elevation, for the delivery of the water. This last condition is likely soon to be realized, upon which the other two are not unlikely to follow in course of time.

Air-valves. —The office of automatic air-valves on a steel or wrought-iron pipe-line is to let the air out of the pipe when it is being filled with water; to let the air into it again when the pipe is drawn; also, to let air into the pipe, and thus prevent the collapse of a long stretch of pipe, should, by any accident, such as a breakage of a blow-off connection, or of the pipe itself, a large quantity of water suddenly flow out of the pipe. To this has been added in the same casting an ordinary valve, by means of which accumulated air may be let out of the pipe while it is in operation. The basis of the automatic air-valves is a brass cup, $3\frac{1}{16}$ inches in outside diameter, and 4 inches high, turned bottom up, and light enough to float on water. The upturned bottom forms the valve disc, which is made to set up against the valve-seat, when the cup, floating up between brass guides, and after the air contained in the pipe has been blown out, is reached by the rising water. The air imprisoned within the cup forms an air-cushion for this upward thrust. When the water leaves the cup, it at once falls down between the guides already mentioned, and thus leaves the whole area of the air-valve open for the entrance of air. These cups are mounted in

clusters of four, six, and ten, being the equivalents of 6-in., 8-in., and 10-in. connections, and each cluster is fitted with a valve to be operated by hand, as already mentioned. Under each cluster is a shut-off valve, to be used in case of any defect in the air-valves requiring repairs. The air-valves used were made by the Coffin Valve Company, of Boston, Massachusetts, who also made the Intake Gate-house sluice-gates, and gate-house ironwork generally; all of it, in the most satisfactory manner.

These air-valves were proportioned such that in the event of the pipe being cut in two at the most dangerous point, the water rushing out and air rushing in would, between them, at no time cause more than ½ atmosphere of vacuum inside the pipe.

As the pipe was barely finished in 1891, there was no time to build underground vaults to keep these air-valves from freezing. Instead of these, there was designed a most wonderful structure, as such things go, called an air-valve box. It must let air in freely, and let air out freely, according as the pipe is drawn or is filled, but it must not allow the valve to freeze up. It must afford access to the hand-valve and to the air-valve, and must let air or water out when the hand-valve is opened, but again must not let any of the valves freeze up. It must let out the water that spills at the moment when the air-valves are shut by the rising water, or the possible larger quantities, should, from some obstruction or defect, one of the air-valves fail to close tight; but, again, must not let things freeze up by the route taken for the water to get out. The great American boy must be prevented from dropping stones or sticks into the boxes, and the shut-off valve must be so fitted that it can at any time be operated. The drawings will show how these several requirements have been met. A cellar pit is first built around the air-valves, and this is floored over with loose boards, or with panels of such. On this is laid a cheap form of quilt, made in two halves. The ordinary straw or other winter stuffing will not apply in this case, for fear of pieces of straw or other stuffing getting into the valves. Over this is the box proper, pierced by two or four wooden square chimneys, hooded to keep out the rocks and sticks. In these chimneys swings a flat plate of sheet-iron, which shuts off the chimney when this plate is in a horizontal position. It is normally held horizontally, by a lead ball attached vertically beneath the centre of the plate by a short wire rod, but will swing out of its horizontal position to pass a current of air going either up or down the chimney, and will duly return to the normal position when the air-current ceases. Flap-valves in the several outlet pipes perform the same office of keeping out the cold, as far as they are concerned. The rest of the design of these air-valve boxes is made clear by the drawing. The author presents the finished and tried air-valve box to the profession, without showing the successive steps by which it was developed from the trial air-valve box first designed. That no valve froze up during the very trying first two winters of the operation of the pipe is praise enough for the box as shown.

Blow-offs and Manholes. — It goes without saying that blow-offs had to be provided at all depressions, so that the pipe could be emptied; and manholes placed at proper distances, so that the interior of the pipe could be visited during and after construction. On the 48-in. pipe there are manholes every 1,000 feet; on the 36-in. pipe, every 500 feet.

Manifold Connections.— To connect or branch off a 36-in. from the 48-in. pipe, as was done at Pompton Notch and at Belleville, the neatest way seemed to be to do this by a series of 16-in. thimbles riveted to the 48-in. pipe, which were then gathered together again into the desired 36-in. pipe. All of which is shown on the drawings.

Venturi Water-meters.— As the main 4-ft. conduit is to supply several municipalities, a metering of the water carried by it and by its branches had to be provided for. For this purpose there exists, so far as the author knows, but one practical meter at the present day, described by him in the Transactions of the American Society of Civil Engineers, November, 1887, and June, 1888, which articles describe also the carefully conducted tests of a 108-in. meter, discharging nearly 250 cubic feet per second, and of a 12-in. meter.[1]

There are on the line of the East Jersey Water Company, up to date, four such meters, two 48-in., one 36-in., and one 16-in. meter, which are shown on the drawings. It may be proper briefly here to repeat a description of the method of operation of these meters, which is extremely simple. It is based on the properties of the Venturi ajutage, in causing, within limits, the small section of a gently expanding frustrum of a cone to discharge as much water as the large end, without material resultant loss of head; and on that further property, which causes the pressure of the water flowing past the small section to be less, by virtue of its greater velocity, than the pressure thus exerted at the large end; each pressure being at the same time a function of the velocity at that point and of the hydrostatic pressure which would obtain were the water still within the pipe. The apparatus accordingly takes the shape of two frustrums of a cone set in line of the pipe whose discharge is to be metered, with their two small ends joined by a short throat-piece. The water pressure is measured just up-stream from the large end of the first cone, and again at the throat. The difference of pressure at these two points forms a most exact measure of the mean velocity through the throat, and the total loss of head caused by the whole apparatus can be kept within desired limits by a proper proportion between the area of the main pipe and of the throat. Ordinarily this proportion is between $\frac{1}{9}$ and $\frac{2}{9}$, and so long as the velocity through the throat of the meter is less than about 24 and 34 feet per second, the total loss of head caused by the meter will be less than one foot and two feet respectively. The 48-in. Venturi meters above mentioned will pass 25,000,000 gallons per day, with a loss of head due to passing the meter of only four inches of water column.

Algebraically stated, the theory of the meter is as follows:

Let P be the pressure, in terms of the height of a column of water, at the up-stream end of the meter.

Let P_1 be the pressure, similarly expressed, at the throat.

Let v and v_1 be the velocities of the water, at the same two points, respectively.

Let Ps be the static pressure; then

$$P = Ps - \frac{v^2}{2g}$$

$$P_1 = Ps - \frac{v_1^2}{2g}$$

[1] See also Vol. vii. p. 32, this Journal.

Also: $v_1 = 9v$, from the construction of the meter, in the case that the diameter at the throat is $\frac{1}{3}$ the diameter of the main pipe. Subtracting the equations we have

$$P - P_1 = \frac{80}{81} \frac{v_1^2}{2g}.$$

But $P - P_1$ is the difference of pressure at the two piezometers, and is the head on the "Venturi," or on the throat. Calling this H_v, we have v, the velocity through the throat,

$$= \sqrt{\frac{81}{80}} \sqrt{2\, gH_v} = 1.0062 \sqrt{2\, gH_v};$$

whereas experiment on meters of 12, 48, and 108 inches diameter gives for extreme values in the three meters, within their range of capacity to meter, $v = 1.02$ to $0.90 \sqrt{2\, gH_v}$; varying with the velocity through the throat, and more especially when approaching the lower limit of velocity. For more than $\frac{3}{4}$ of the extreme range of capacity to meter, this range of coefficient for the *three meters* is only between 1.00 and 0.94. These figures show what may be expected from any meter, set to work without first testing it; but any one meter after having been rated, will record within a small fraction of one per cent. of the exact quantity passing the meter.

Before the piece of main conduit pipe which immediately adjoins the Intake Gate-house was set in place, an open wooden flume was built to convey the water from the gate-house to the pipe already laid. A carefully constructed weir was set in this flume, and a series of experiments were made to determine the discharge of the Venturi meter set in the conduit; also of the gate-house sluice-gates, under varying conditions of quantity and of head. These two sets of rating were carried on simultaneously, as the same stream of water passed first the sluice gates, then the weir, then the Venturi meter. And the results of these ratings will be given later. It will be noticed that the rating of the 48-in. Venturi meter made in 1891 agrees perfectly with the ratings of the 108-in., and of the 12-in. meter made in 1887.

So far, the Venturi meter has been described as forming an apparatus by means of which only the rate of flow in a pipe can be measured at any desired moment of time. But the Builders' Iron Foundry, of Providence, Rhode Island, which builds these meters, has added a recording gauge or recorder, which causes the Venturi meter to register quantities (cubic feet or million gallons) in precisely the same manner that ordinary meters register quantities.

This recording and integrating gauge has never yet been publicly described, but is on exhibition at the World's Columbian Exposition. There may be an electrical connection between the dials and the mercury gauge, thus permitting the former to be set up at any distance from the latter, which at times becomes very convenient. Besides this, the recorder itself can be set up hundreds of feet, if need be, from the Venturi meter, for it is operated by two pipes conveying water *pressure* only (not a current of water), and such pipes need have but a small diameter, and can convey such pressure through any reasonable length of pipe.

Making of the Conduit. — The conduit is made of open hearth steel, bought to conform to the following specifications, as to quality:

"Tensile specimen to be eight (8) inches long and one and one-half (1½) inches wide between measuring points. Tensile strength to be between the limits of 55,000 and 67,000 pounds per square inch. Elastic limit to be not less than 30,000 pounds per square inch. For plates ⅝ inch thick and heavier, elongation to be not less than 25 % longitudinally on the plate, 22 % transversely on the plate. Plates thinner than ⅝ inches, elongation to be not less than 22½ % longitudinally, and 20 % transversely on the plate.

"Bending specimen to be six inches long and one inch wide, and to be hammered down flat, when cold, without showing cracks.

"Test to be made from 20 % of the plates selected at random.

"Steel to contain not more than six one-hundredths per cent. phosphorus, and six one-hundredths per cent. sulphur, and sixty one-hundredths per cent. manganese."

This high quality of metal was chosen so as to leave no doubt as to the expediency of punching the plates, instead of drilling, or of punching and reaming them. This selection of steel cost the Water Company $85,000, as Bessemer plates could have been bought for that much less; but no $85,000 spent on the works was probably better invested. Apart from the advantage of being able to punch the plates without injury to them, there has seemed to be no expected or unexpected strain to which the pipe has been subjected, that it has not been able, largely by virtue of the superior metal of which it was constructed, to withstand without injury.

This steel was from the works of Carnegie, Phipps & Co., and was shipped in plates from Homestead, Pa., to the pipe works at Paterson, in cars especially built for the purpose, by the Lehigh Valley Railroad Company, as fully described below.

Shop riveting was done by machines, and using open hearth steel rivets, of a tensile strength between 57,000 and 63,000 pounds per square inch, and of an elastic limit of 30,000 pounds.

Field riveting was done by hand, and using iron rivets of a tensile strength of 55,000 pounds, and an elastic limit of not less than 27,500 pounds.

Each length of pipe as shipped on railroad cars was made up of four plates, each plate seven feet wide, and long enough to make one section of the pipe; making about twenty-seven feet of pipe, made up of two long sheets and two short ones. Various data with regard to such a length of pipe are given in the accompanying table.

General Dimensions.	Inches.	Inches.	Inches.	Inches.
Nominal size pipe.....	48	48	48	36
Thickness sheets.	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{4}$
Size large sheets.....	$154\frac{3}{4} \times 84$	$155\frac{3}{8} \times 84$	$156\frac{1}{16} \times 84$	$118\frac{3}{4} \times 84$
Size small sheets.....	$153\frac{1}{8} \times 84$	$153\frac{1}{4} \times 84$	$153\frac{3}{8} \times 84$	$116\frac{7}{8} \times 84$
Inside diameter of large ring..	48	48	48	$36\frac{1}{2}$
Inside diameter of small ring..	$47\frac{1}{2}$	$47\frac{3}{8}$	$47\frac{1}{4}$	36
Size of rivets.....	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{5}{8}$
Size of rivet-hole	$\frac{11}{16}$	$\frac{13}{16}$	$\frac{15}{16}$	$\frac{11}{16}$

Circular Seams.	Inches.	Inches.	Inches.	Inches.
Number of rivets per seam ...	100	84	76	76
Circumference of large sheets,	151.582	151.779	151.975	115.641
Circumference of small sheets,	149.895	149.717	149.538	113.883
Rivet pitch, large ring	1.515	1.807	2.053	1.521
Rivet pitch, small ring	1.498	1.782	2.020	1.498
Distance from centre rivet to edge plate.....	1	$1\frac{3}{16}$	$1\frac{3}{8}$	1
Lap of sheets at circular seam..	2	$2\frac{3}{8}$	$2\frac{3}{4}$	2

Longitudinal Seams.	Inches.	Inches.	Inches.	Inches.
Number of rivets in first row..	35	29	25	35
Number of rivets in second row,	34	28	24	34
Rivet pitch, both rows	2.277	2.721	3.125	2.277
Distance between rows	$1\frac{1}{16}$	$1\frac{3}{16}$	$1\frac{5}{16}$	$1\frac{1}{16}$
Diagonal pitch.....	1.557	1.806	2.041	1.557
Distance pitch line to edge plate,	$\frac{15}{16}$	$1\frac{5}{32}$	$1\frac{11}{32}$	$\frac{15}{16}$
Lap of sheets.....	3	$3\frac{1}{2}$	4	3

The California practice is to carry a portable punch, shears, and bending-rolls into the field, and make all bends needed to fit the ground, on the spot. On the work of the East Jersey Water Company the engineer corps devised the plan of forming all bends by means of only four standard bevels, used in combination with the standard 28-ft. length of chord, or of straight pieces of pipe. This made curves of 2½, 5, 7½, and 10 degrees of curvature, and no other curves were used on the survey of the pipe line. Vertical curves, also, were made on 10 degrees of curvature. So that the whole pipe was laid out in the shop, to fit the ground as it had been surveyed; each piece was tagged with a tin tag and number, signifying where it belonged on the line, and was laid in the ditch at the points corresponding to its tin tag without further fitting or trimming.

The author being strongly of the opinion that to insure the preservation of any metal from rust it is necessary to coat the same before any rust has begun to form, great pains were taken to get the plates from the rolling-mill to the pipe-shop in a clean and bright condition. Several plans for this were tried without success. One of them consisted in dipping the plates in paraffine at the rolling-mill, and failed on account of the resultant difficulty in passing such coated plates through the bending-rolls. The system finally adopted was to have 40 special cars for this "trade" alone, and to keep constantly passing the loaded cars to the shop, and the "empties" back to the rolling-mill. These were new coal-cars, with deep bodies, and with a specially constructed, removable flat roof, as a cover for the plates; made in two sections, and flat enough for brakemen to walk on. These roofs could be lifted off and put on by the same cranes that handled the plates. Both loading and unloading being done under cover, the plates, when everything was going well, were shipped, received, made into pipe, and dipped, before rust had a chance to show itself.

The dipping was done in iron vats built especially for the purpose, one length of pipe at a time. The material used to dip into was asphalt, from Southern California. Asphalt is found in Southern California in two forms: (1) combined with 40 to 60 % of sand, making rock asphalt; and (2) in liquid form, being combined with a species of petroleum. To use the first, it must be refined; that is, melted out of its combined sand, then remelted, and mixed with a certain proportion, usually, of coal tar, to give it a proper consistency for having pipe dipped into it. The liquid asphalt, on the other hand, must be distilled until the bitumen remains as a residuum; and this, when remelted, is usually mixed to make it more fluid, or viscous, with the product of the same wells, taken at a lesser stage of distillation. The distilled asphalt used on these works was shown by repeated chemical analysis to be 98 % pure bitumen.

The sheets, as received, were punched by gang punches, bevel-planed on the edges, rolled into cylinders, riveted by hydraulic riveters, calked with the pneumatic calker (by hand only in odd places), and twice dipped, as stated, in boiling asphalt.

Four lengths of pipe, two lengths below, two on top, made a neat car-load, and one length at a time was a two-horse wagon-load on good roads, or a four-horse load up the mountains; which brings the pipe to the side of the ditch.

Laying the Pipe. — Pipe-laying commenced Sept. 20, 1890, at the crossing under the Pequannock river. The contract for making and dipping the pipe, delivering it side of the ditch, and riveting it together in the ditch had been let,

January 18, to Messrs. McKee & Wilson, boiler-makers, then of South Bethlehem, Pa. The interval had been spent in getting a shop built, at Paterson, N.J., riveters and other tools made and set up, and generally in getting the pipe works started. In the following April, a contract was made by the Water Company with Messrs. T. A. & R. G. Gillespie, of Pittsburg, Pa., for digging the ditch and back-filling; the contractors for making the pipe contracting at the same time, with the same parties, for riveting the pipe together in the ditch. This was a much better arrangement, making, as it did, two consecutive pieces of work of the building of the conduit: (1) the making and delivering of the pipe, and (2) laying the conduit, that is, digging the ditch, riveting the pipe together in it, and back-filling over the pipe; instead of, as before, having the Water Company dig the ditch and back-fill it, with the riveting together of the pipe by another party, in between these two operations.

About 1½ miles of pipe were laid in 1890, this work coming to a stop with the hard frosts of December.

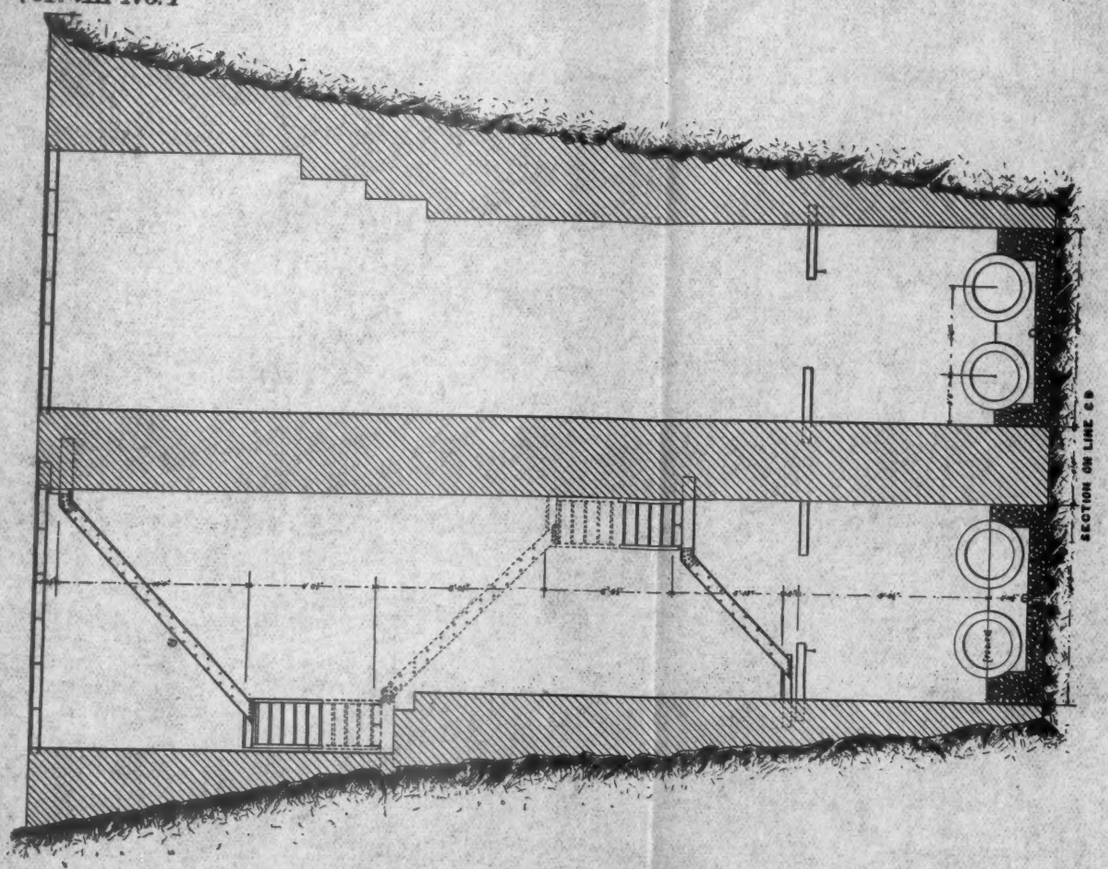
The settled method of laying pipe soon came to be to rivet two lengths together, side of the ditch, making a 54-feet length; to lower these 54-feet lengths into the ditch, and connect them by bolts, temporarily. Then rivet up; each circular joint being made, the lower half from the inside, the upper half from the outside. Cover the pipe as soon as possible with earth, as a guard against undue expansion and contraction, taking care to tamp well up to a point either side of the pipe, which is somewhat above the horizontal diameter of the pipe. If need be, cover in this way before all the field joints are riveted, and leave uncovered only the joints yet to be riveted. Protect both inside and outside the pipe with old canvas, carpets, etc., in a careful manner, against abrasion of the asphalt, by the workmen walking on and in the pipe. Have riveters and others wear rubber boots. See that all abrasions of asphalt, caused in transport, are retouched before the pipe is lowered into the ditch.

For retouching pipe in this way, extensive use was made of "P. & B." paint, which is merely asphalt dissolved in bisulphide of carbon, the bisulphide taking the place of the linseed oil of ordinary paint. After this paint is applied, the bisulphide evaporates, and there is left a coating of practically pure bitumen. This paint did most excellent service throughout the work. In June, 22,165 feet of pipe were laid in the ditch, making the maximum month of pipe-laying; though in May, June, and July the average was 19,347 feet.

Pipe-making never exceeded these rates of pipe-laying, when work went on night and day, and usually was much less, because not so hurried. There was no such need of hurrying it, from the fact that pipe-making could be carried on every day and all winter, while pipe-laying had to stop in the winter and in rainy weather. The work of the pipe-shop represents that of three hydraulic riveters, and of enough other machinery to keep them going.

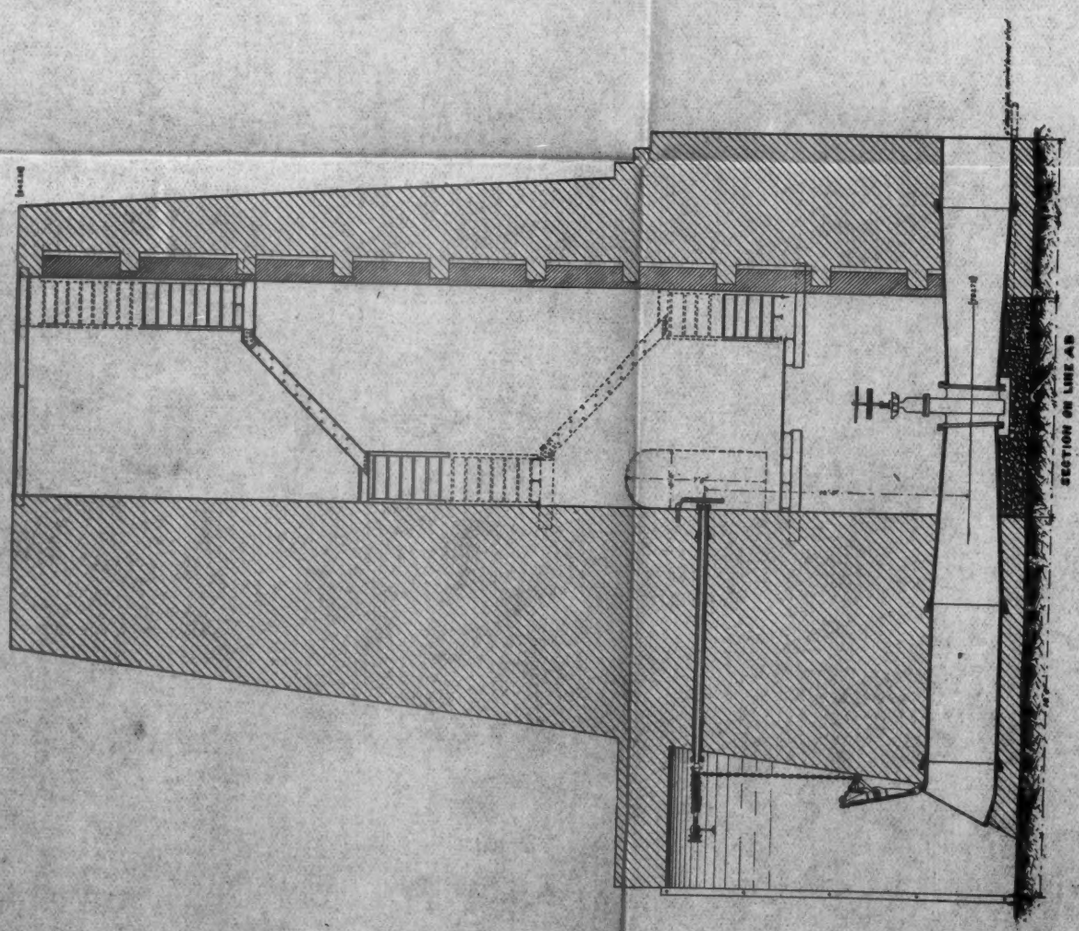
The water was first turned on at 8 A.M., Dec. 30, 1891, while the last manhole plate was screwed down at about 10 A.M., the same day, but at a point some 8 miles from the Intake gate-house.

Before turning on the water, the corps of inspectors of the pipe-work in the field was directed to walk through the pipe, from end to end, in consecutive days' journeys. The 4-foot pipe can be readily walked through, with a little stooping, but to walk through the 36-inch pipe, the inspector must go on his hands and knees, at the same time carrying a lantern in his mouth, or set in his



EA

OAK



THE

AST JERSEY WATER COMPANY

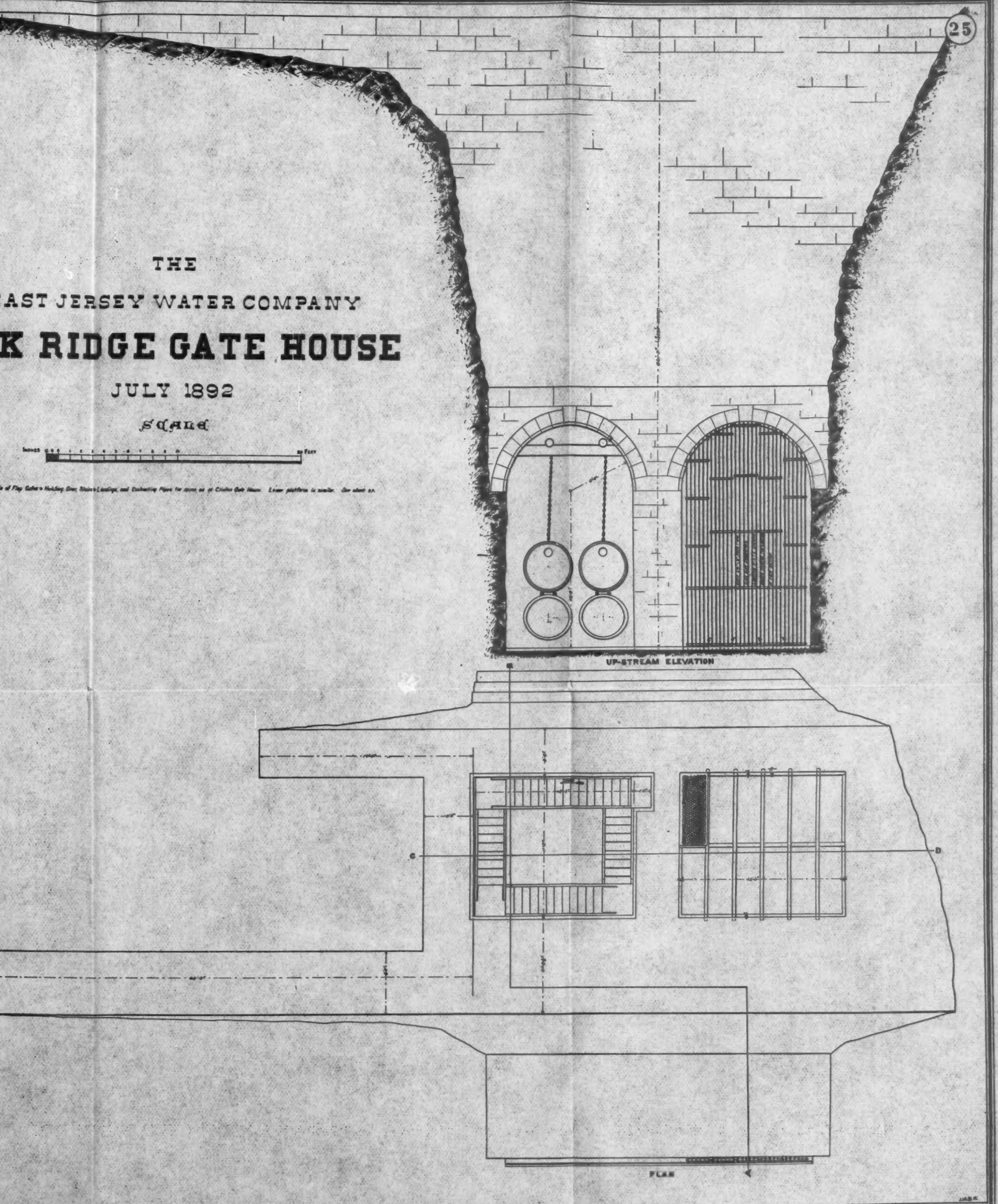
K RIDGE GATE HOUSE

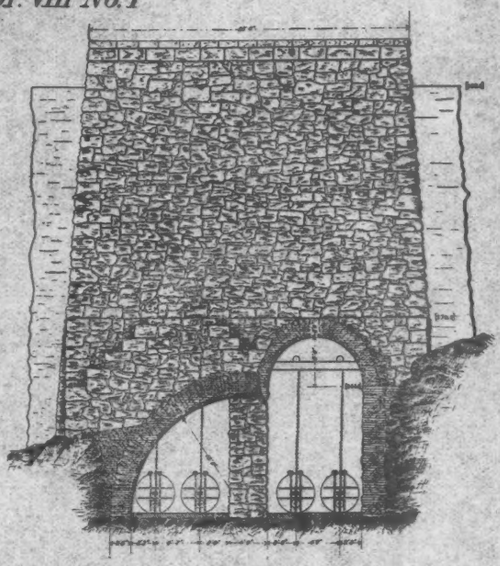
JULY 1892

SCALE

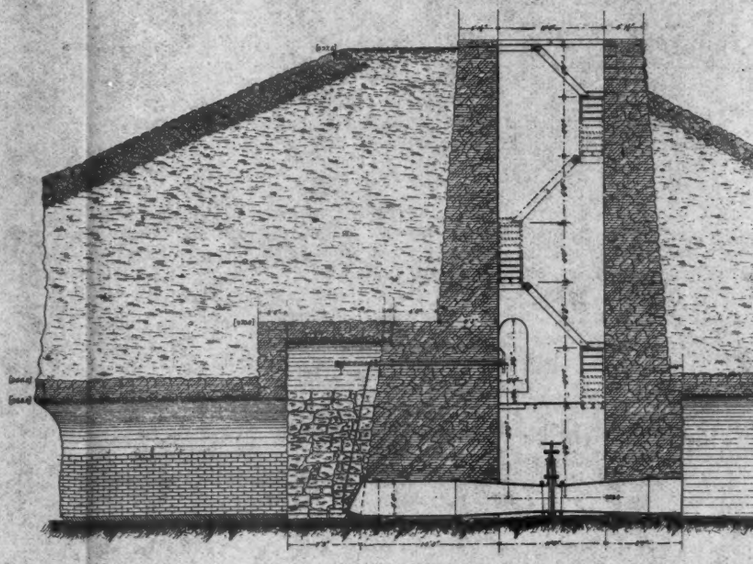
Inches 0 1 2 3 4 5 6 7 8 9 10 11 12 to Foot

of Flap Gates Hackley Gear, Stairs Landings, and Connecting Pipes for drains as at Chicken Gate House. Lower platform is smaller. See sheet no.

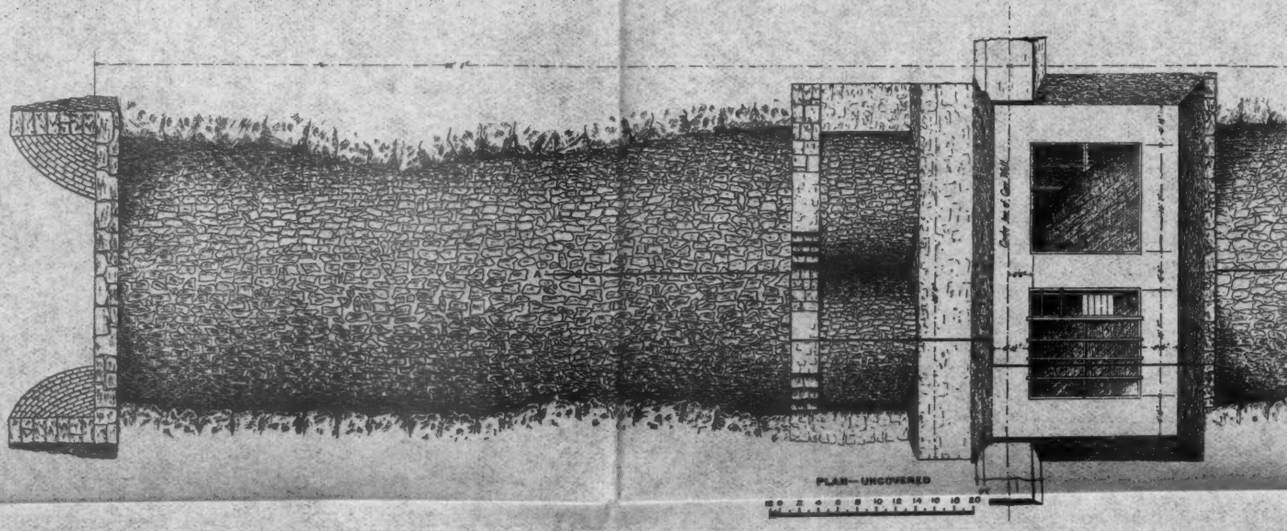




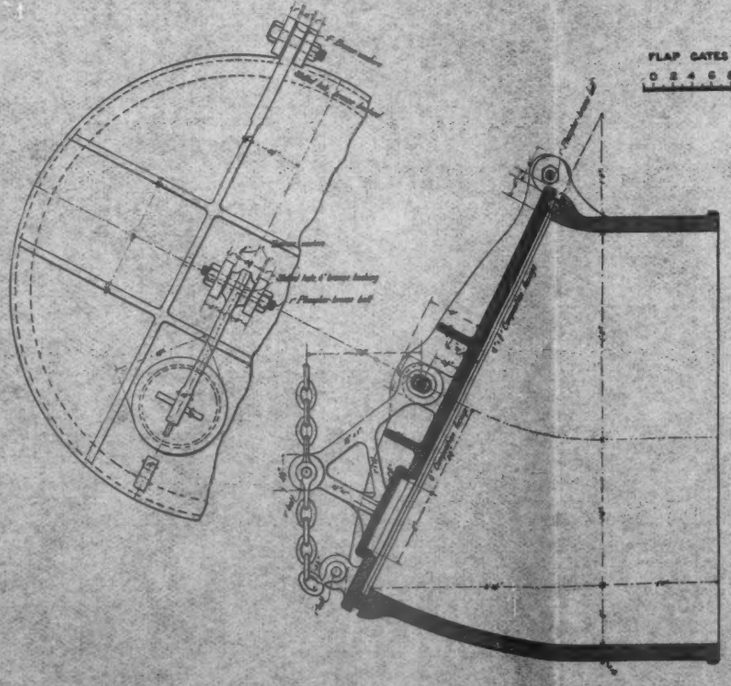
UP-STREAM ELEVATION—UNCOVERED



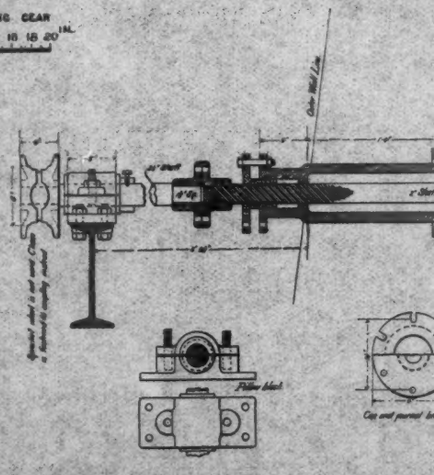
SECTION ON LINE AB



PLAN—UNCOVERED



FLAP GATES — HOISTING GEAR

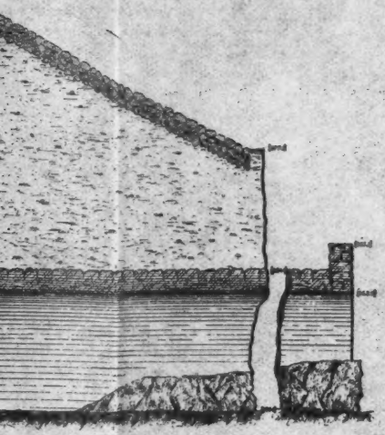


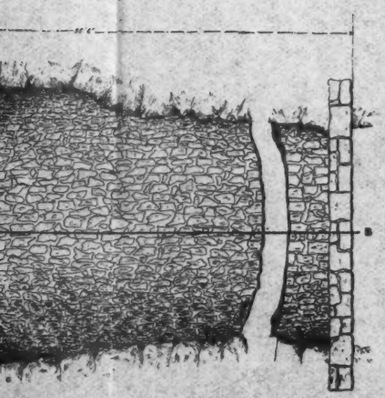
THE

EAST JERSEY WATER COMPANY

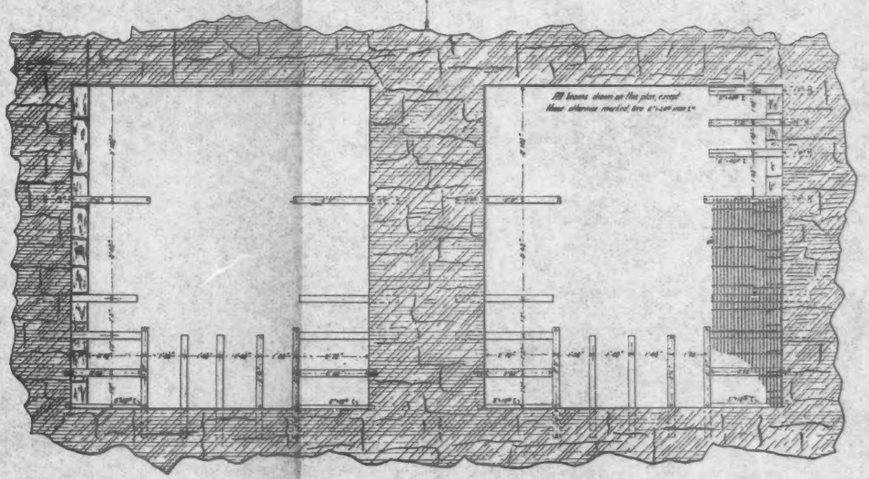
CLINTON GATE HOUSE

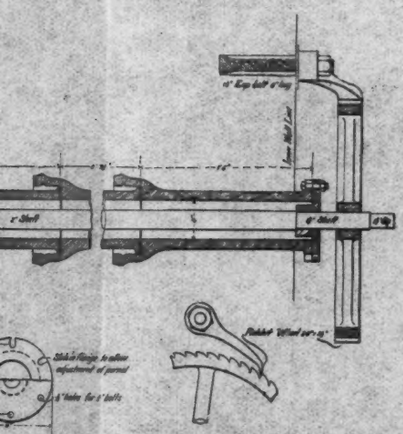
MARCH 1892

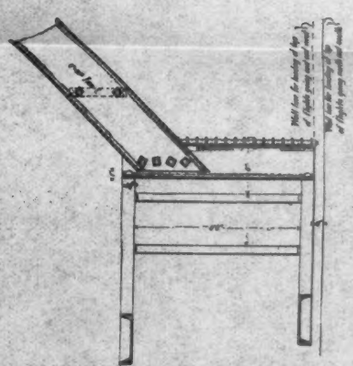




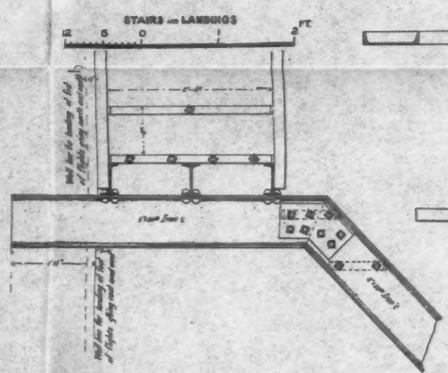
PLATFORM BEAMS

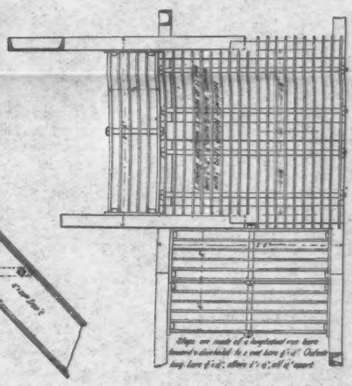




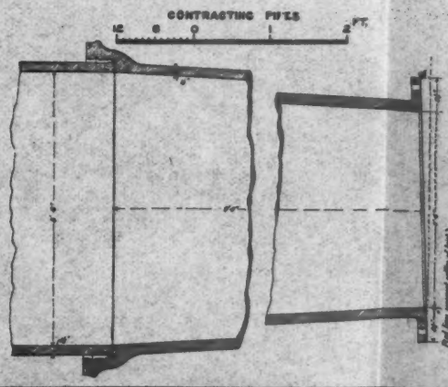


STAIRS AND LANDINGS

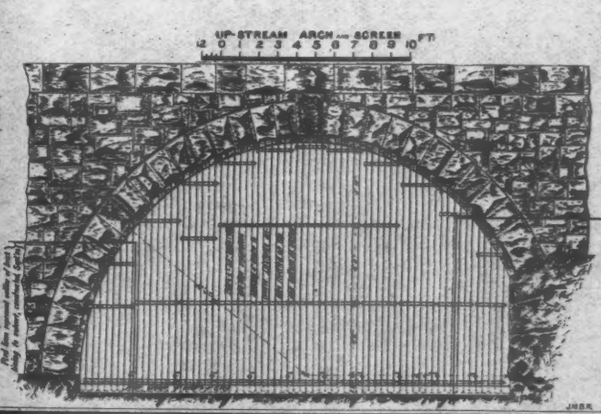


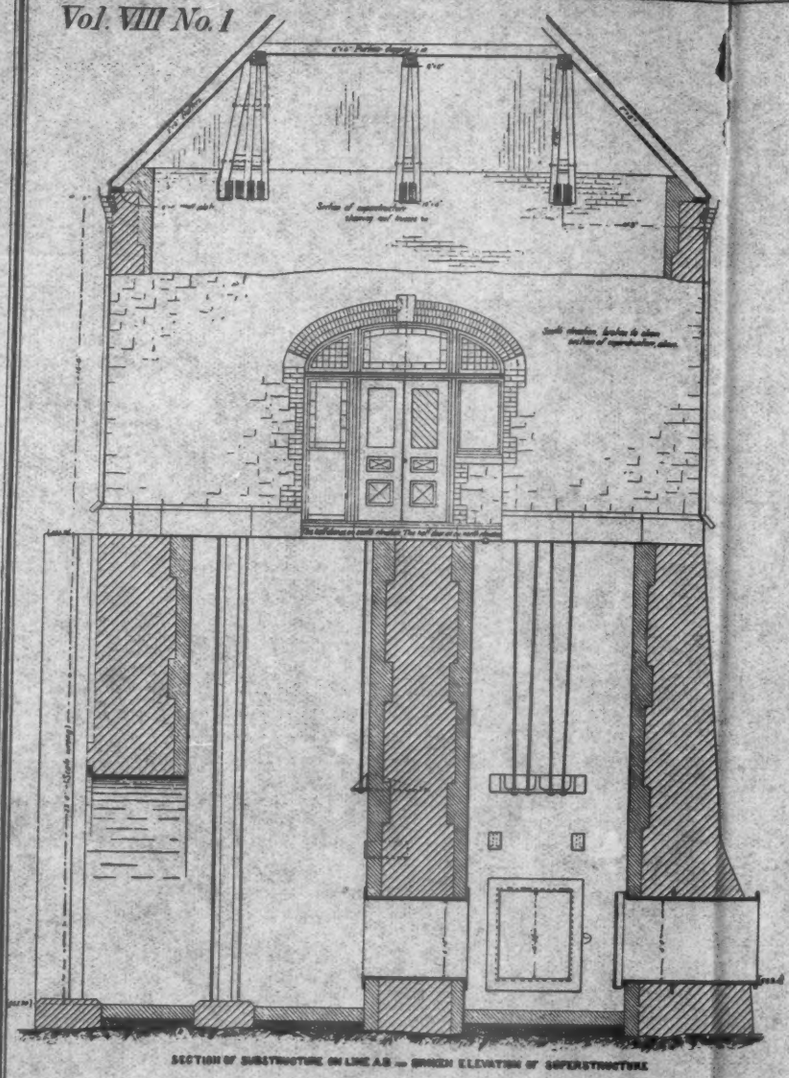


CONTRACTING PIERS



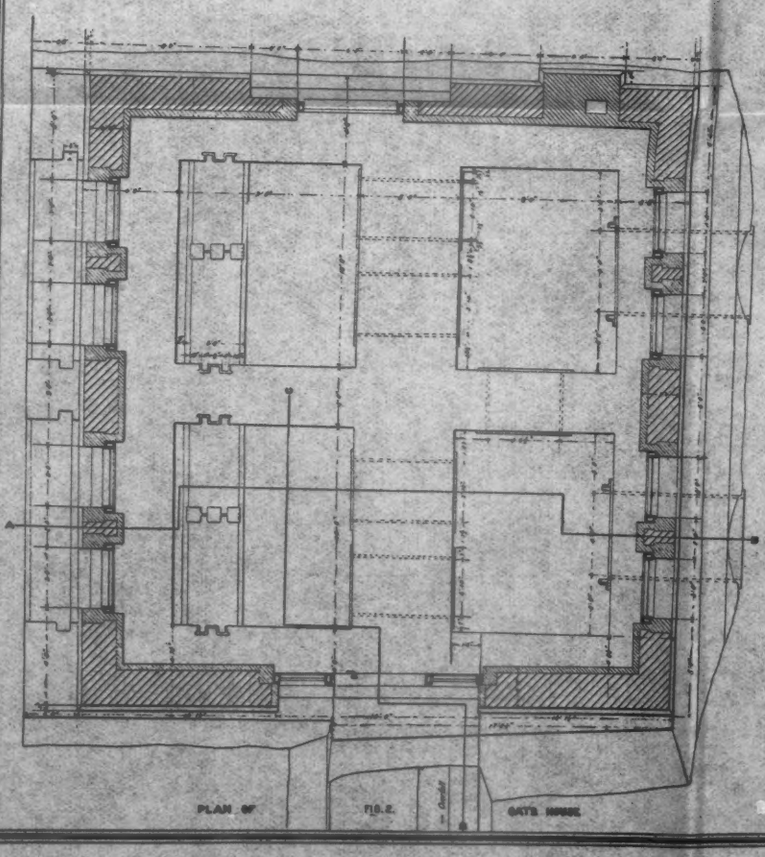
UP-STREAM ARCH AND SCREEN





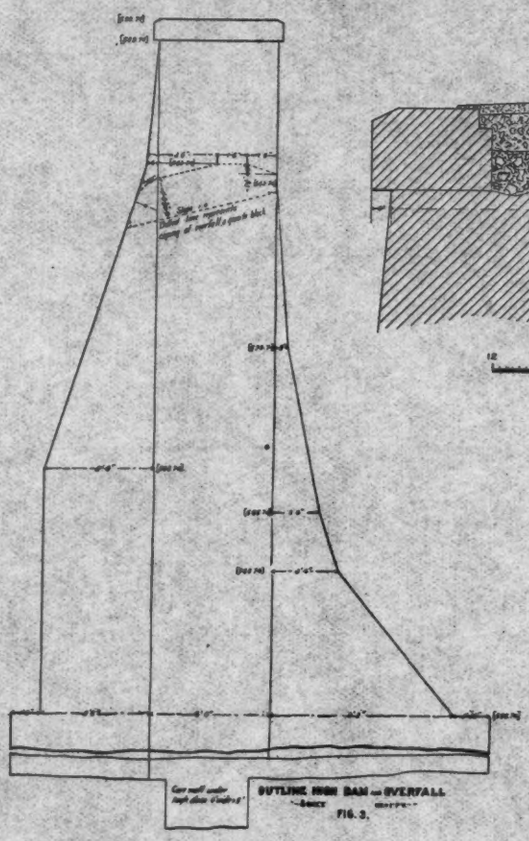
SECTION OF SUBSTRUCTURE ON LINE A.B. AND BROKEN ELEVATION OF SUPERSTRUCTURE

FIG. 1.



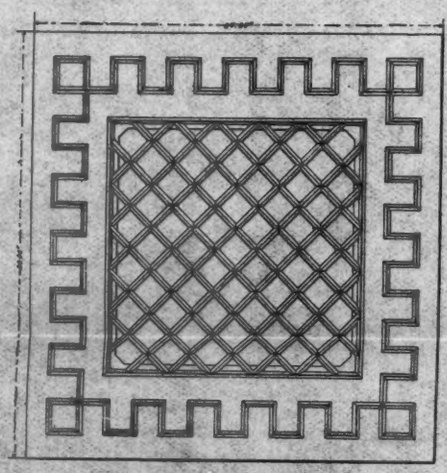
PLAN OF GATE HOUSE

FIG. 2.



OUTLINE HIGH DAM AND OVERFALL

FIG. 3.

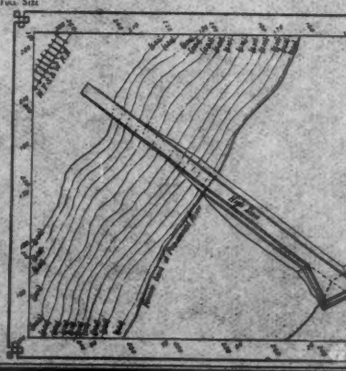


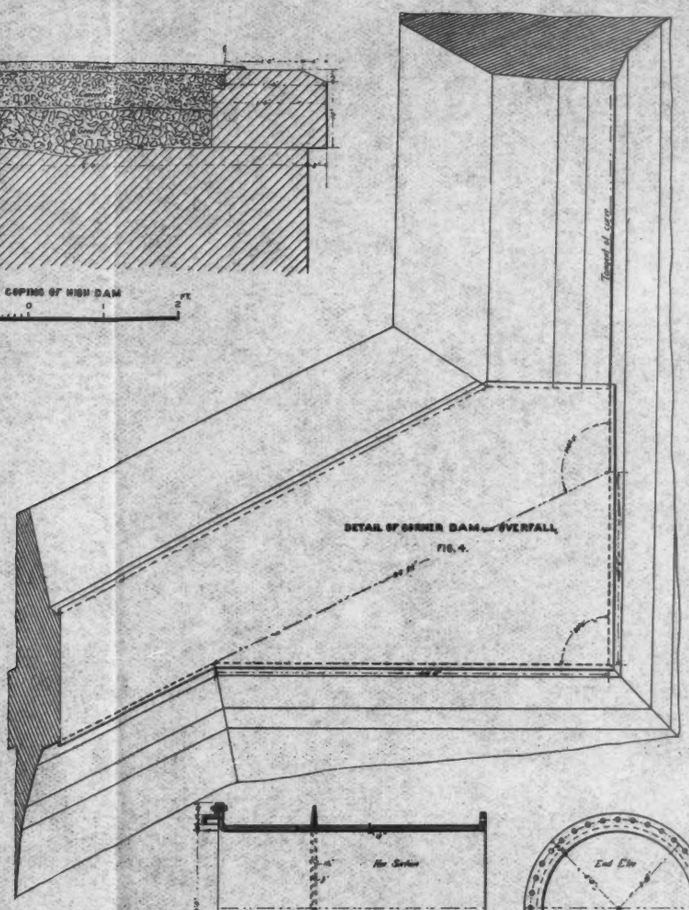
CAST IRON FLOOR PLATES

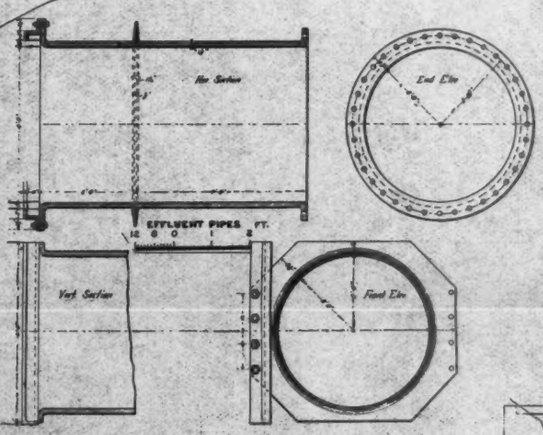
0 1 2 3 4 5 6 7 8 9 10 IN.

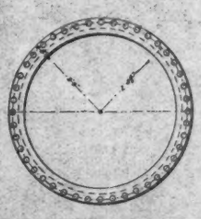
PART SECTION OF THE ABOVE

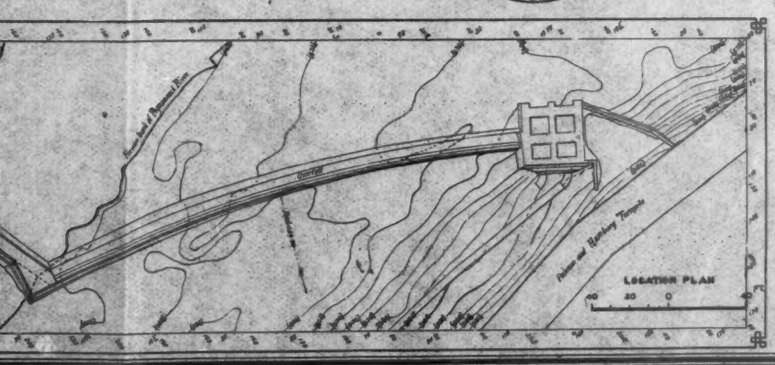
Full Size

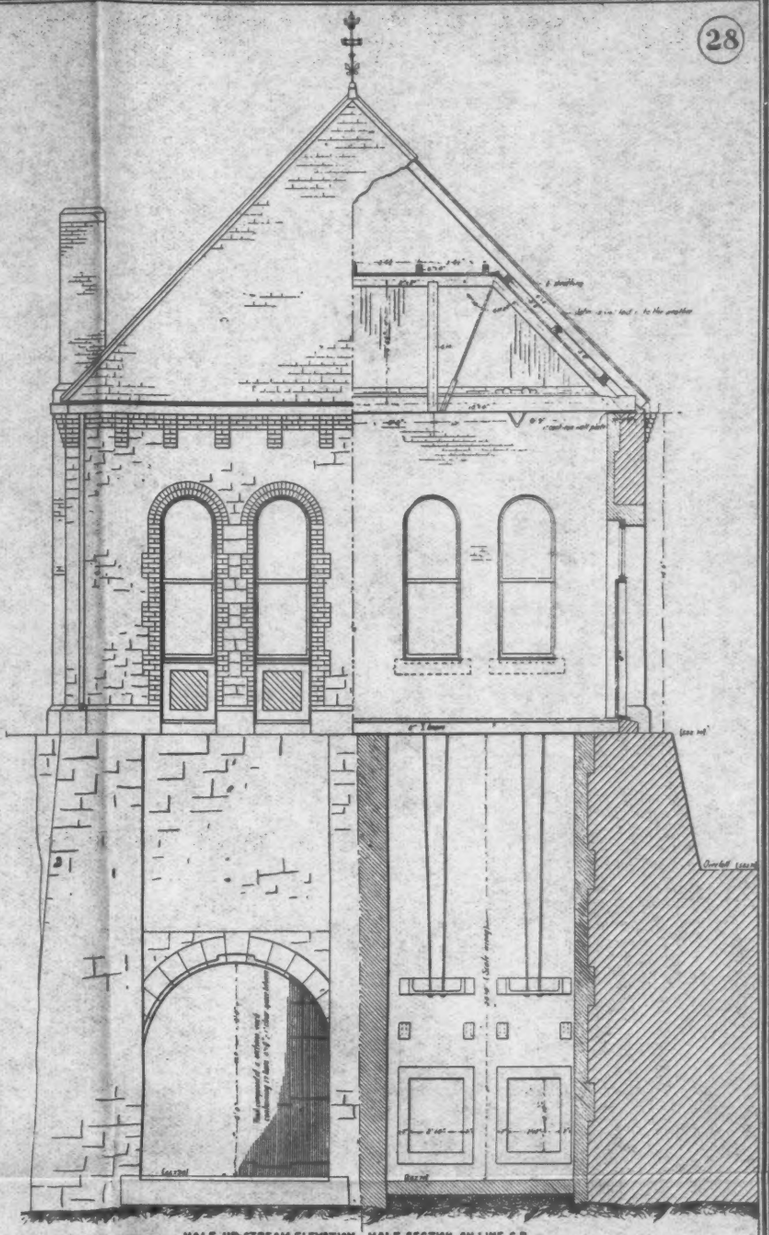


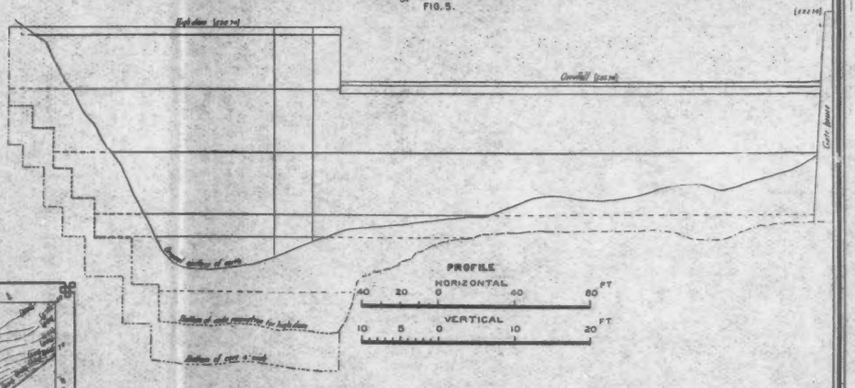











Crest of Dam
Bottom of rock excavation for high dam
Bottom of rock excavation for low dam
PROFILE
HORIZONTAL
60 20 0 40 80 FT
VERTICAL
10 5 0 10 20 FT

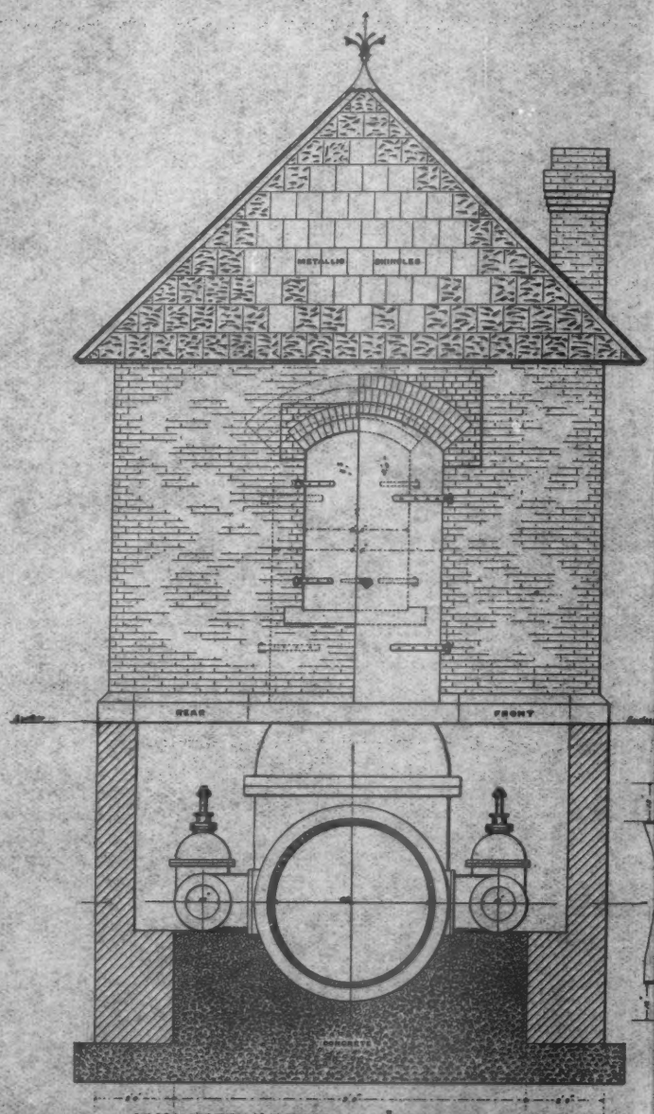
THE EAST JERSEY WATER COMPANY

MACOPIN INTAKE DETAILS

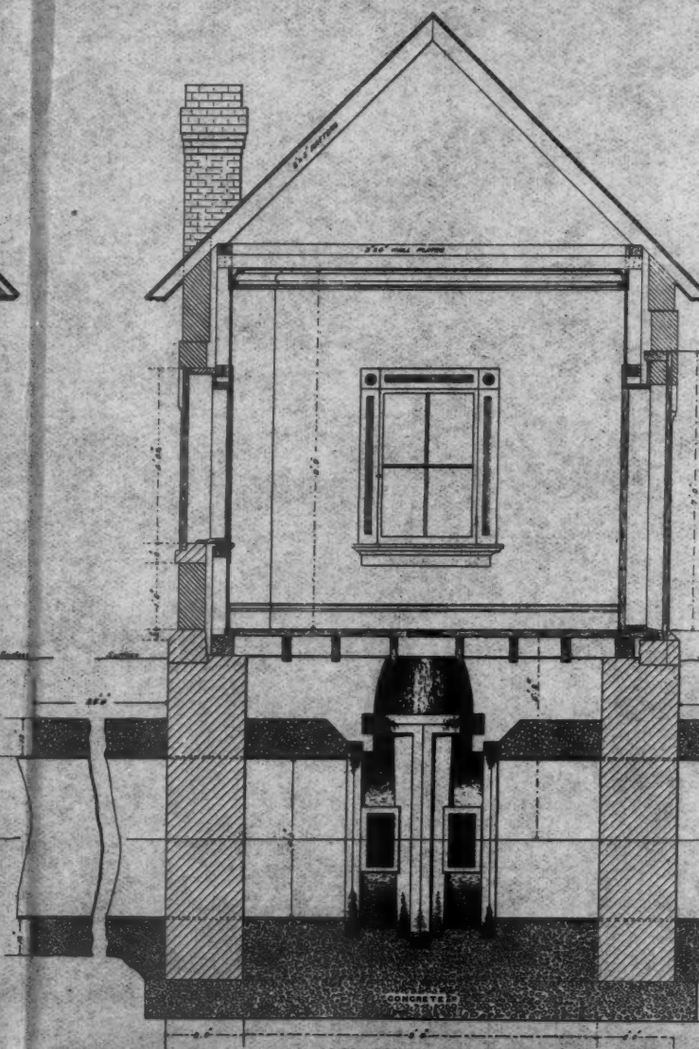
APRIL 1892

SCALE FOR FIGS. 1 TO 5

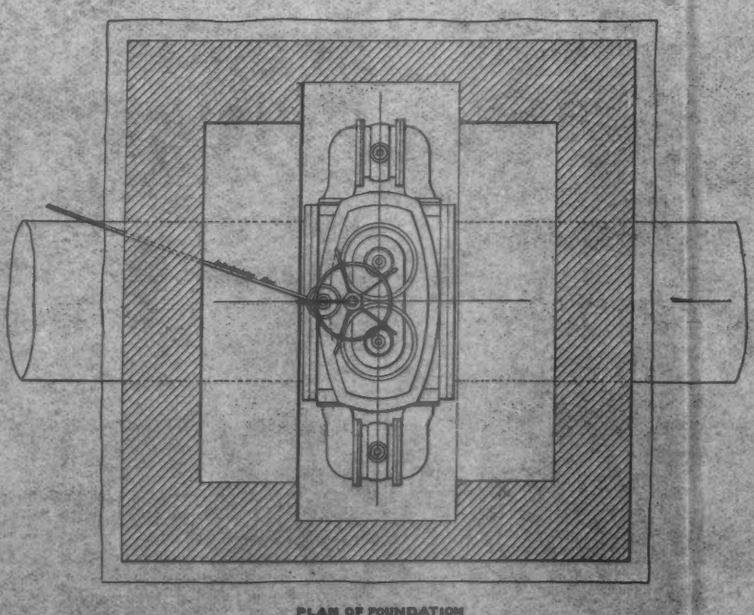
10 0 1 2 3 4 5 6 7 8 9 10 FT



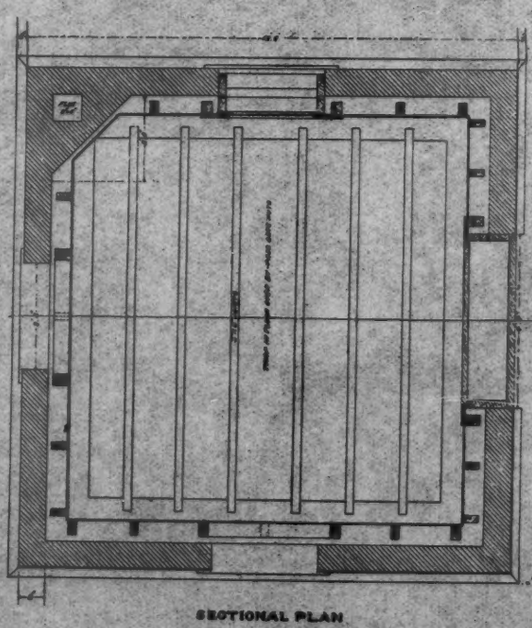
CROSS SECTION & ELEVATION OF 48" CONDUIT GATE HOUSES
FIG. 1.



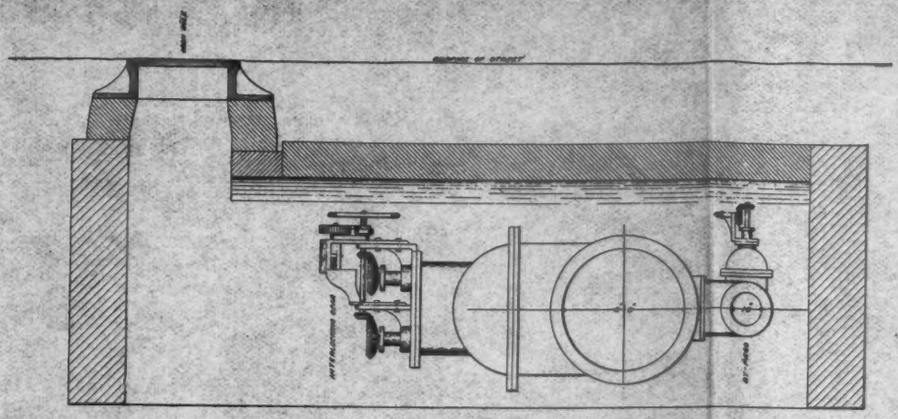
LONGITUDINAL SECTION
FIG. 3.



PLAN OF FOUNDATION
FIG. 2.



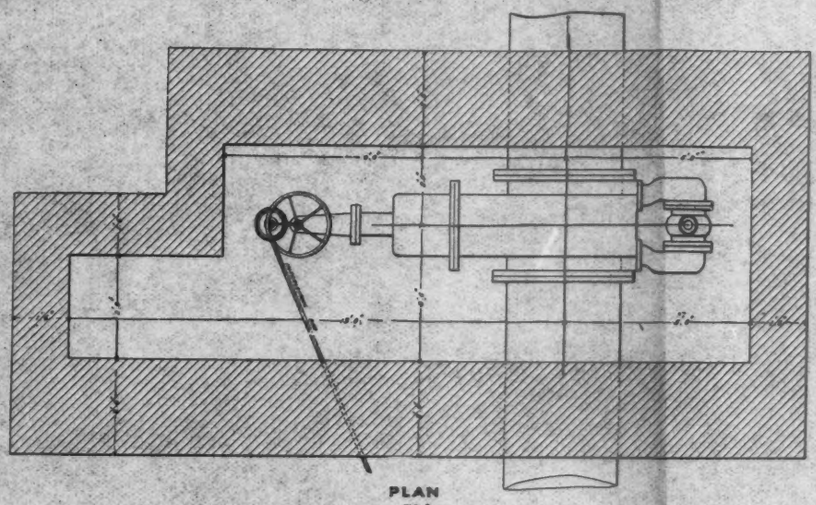
SECTIONAL PLAN
FIG. 4.



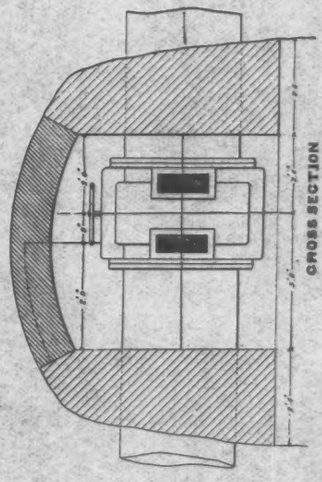
LONGITUDINAL SECTION OF 36" CONDUIT GATE VAULT
FIG. 5.

SCALE FOR FIGS. 1 TO 7.

SCALE FOR FIGS. 8 TO 11.

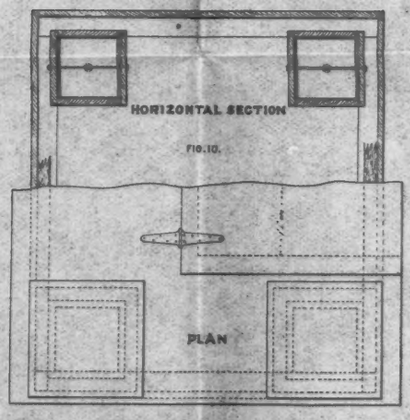


PLAN
FIG. 6.



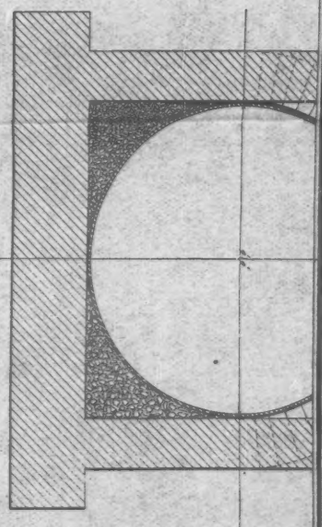
CROSS SECTION
FIG. 7.

SECTION OF TRAP DOOR
FIG. 8.

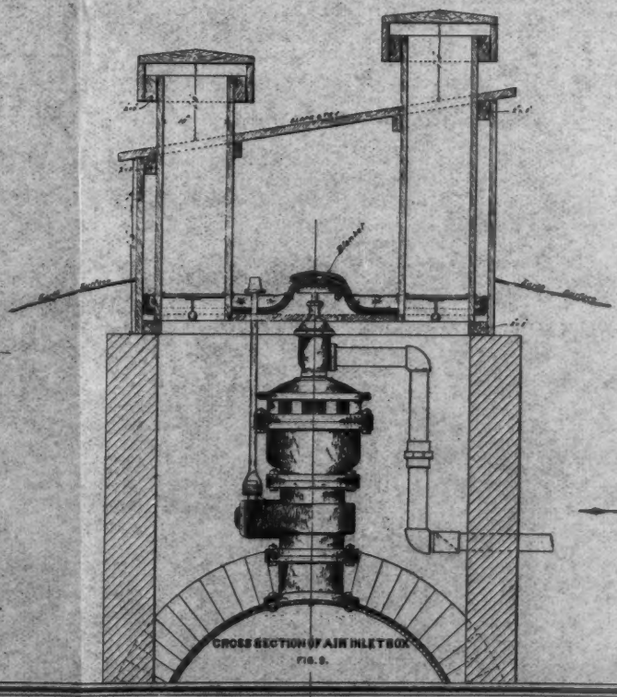


HORIZONTAL SECTION
FIG. 10.

PLAN

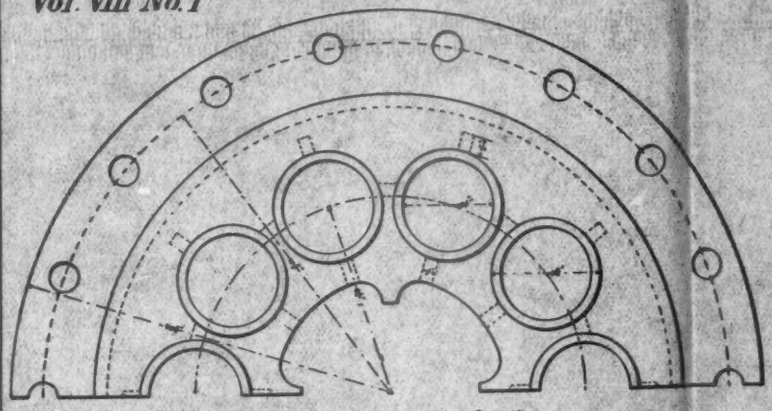


CROSS SECTION OF AIR INLET BOX & VAULT
FIG. 11.

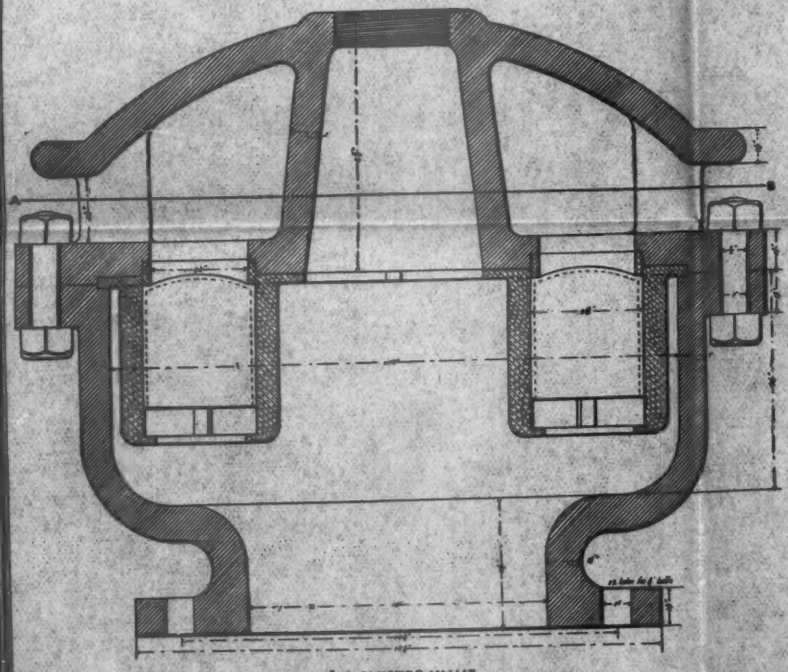


CROSS SECTION OF AIR INLET BOX
FIG. 9.

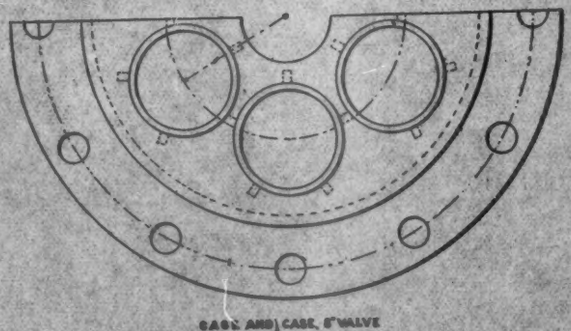
THE
EAST JERSEY WATER COMPANY.
CONDUIT STRUCTURES
JUNE 1892



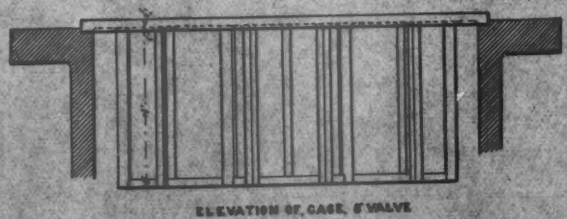
PLAN OF CASE AND CASE. 16" VALVE



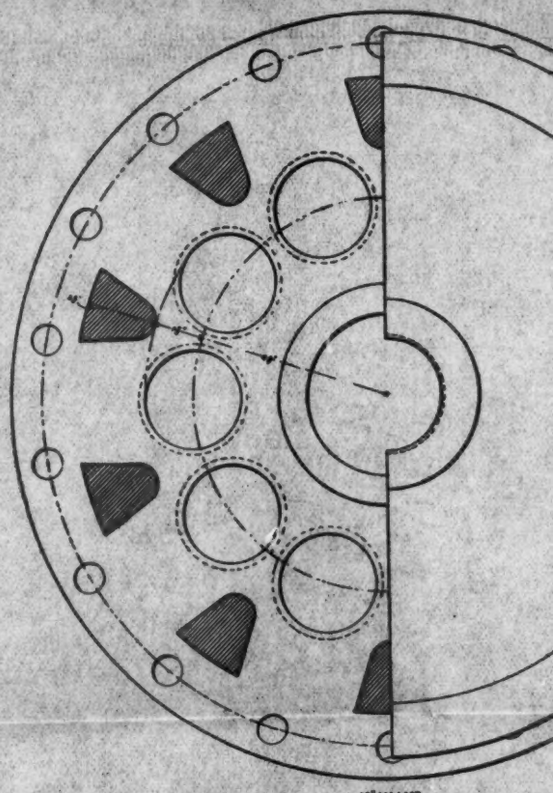
10"x 10 CLUSTER VALVE



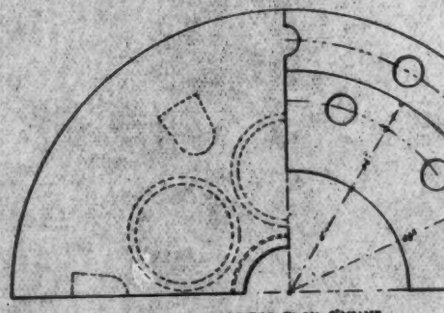
CASE AND LID CASE. 5" VALVE



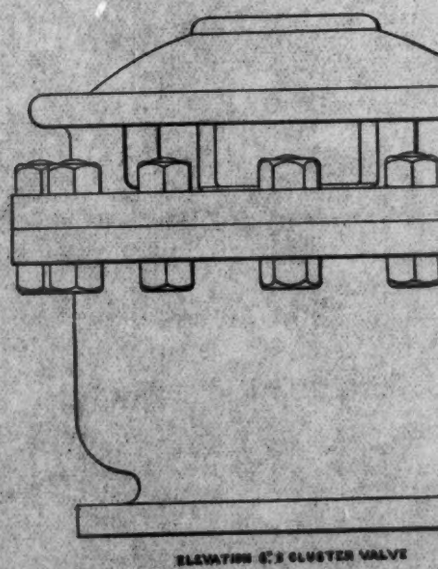
ELEVATION OF CASE. 5" VALVE



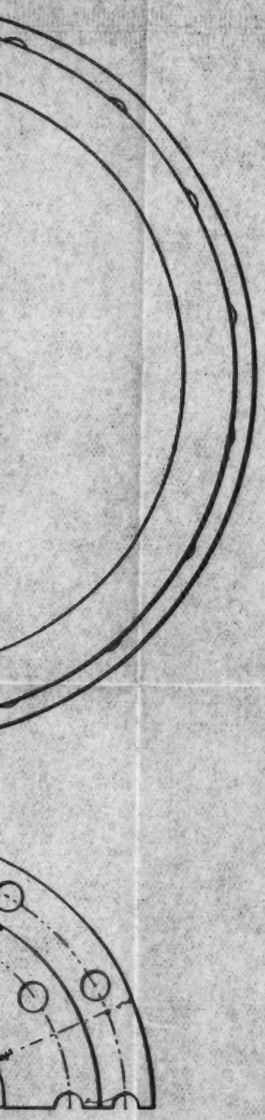
16" VALVE
SECTION AT AB PLAN OF CAP

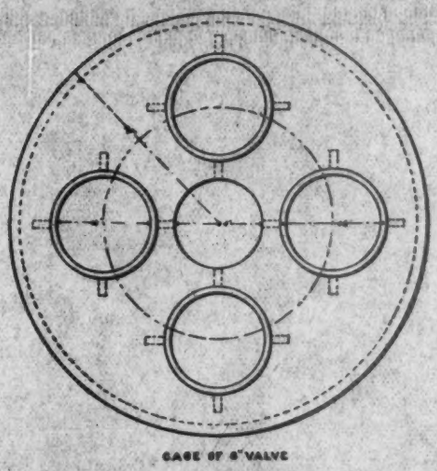


INVERTED PLAN 5" VALVE

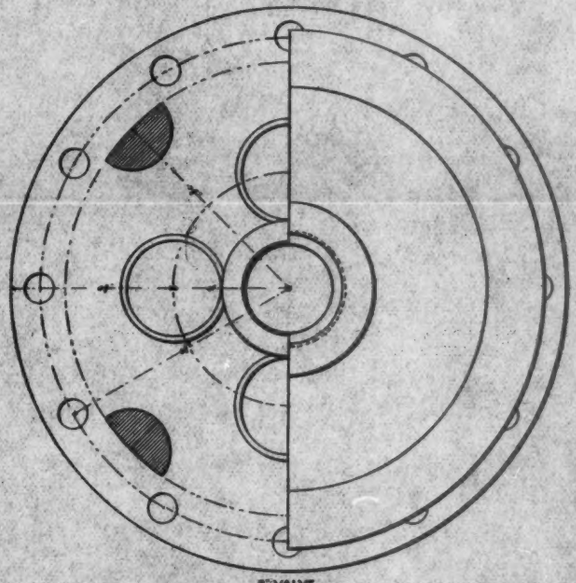


ELEVATION 6"x 6 CLUSTER VALVE

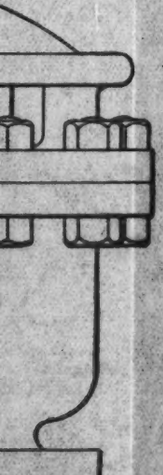


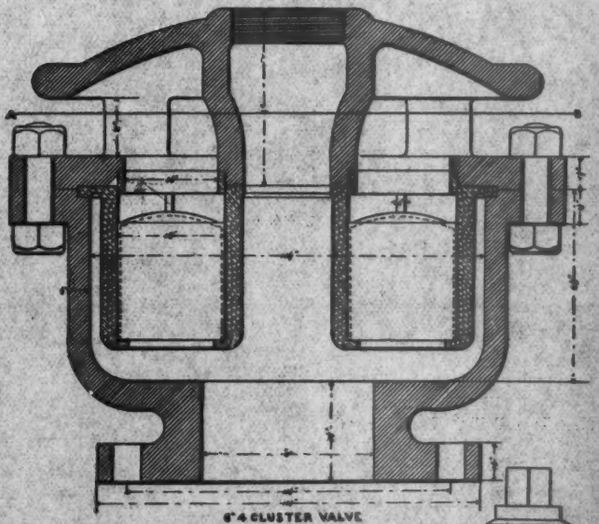


CAGE OF 6" VALVE

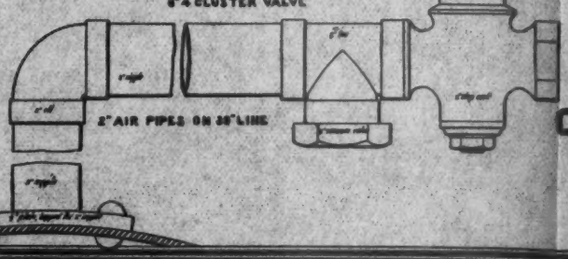


6" VALVE
SECTION AT AB PLAN OF CAP

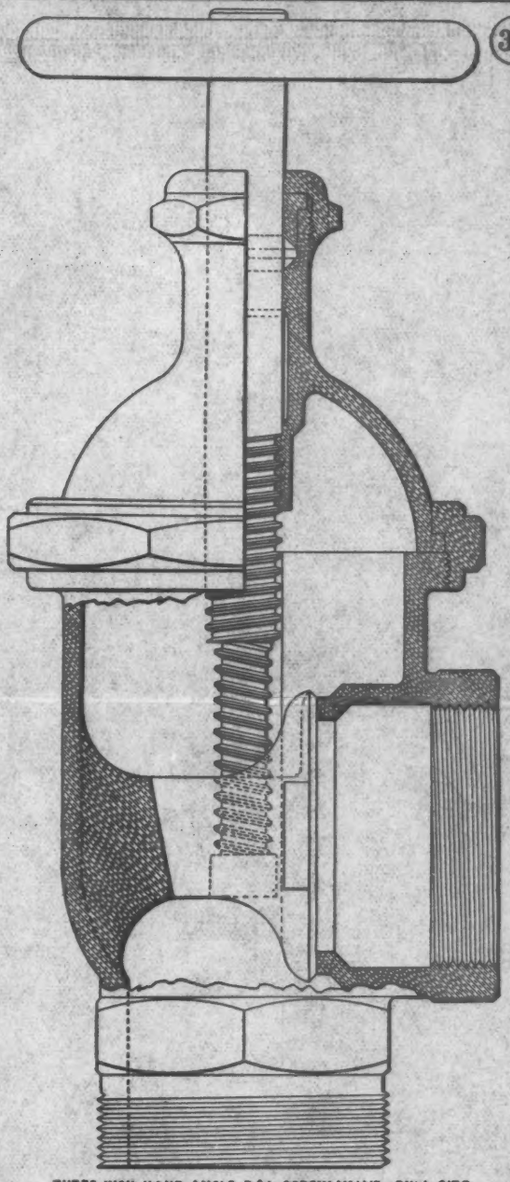




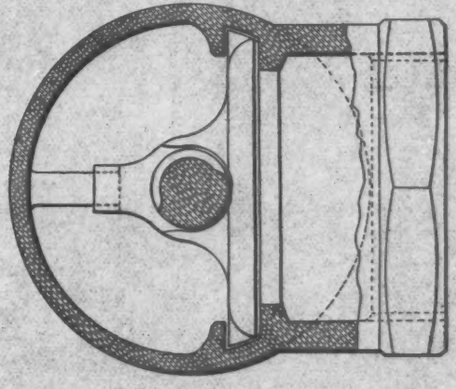
6"4 CLUSTER VALVE



2" AIR PIPES ON 36" LINE



THREE INCH HAND, ANGLE, R.&L. SCREW VALVE – FULL SIZE

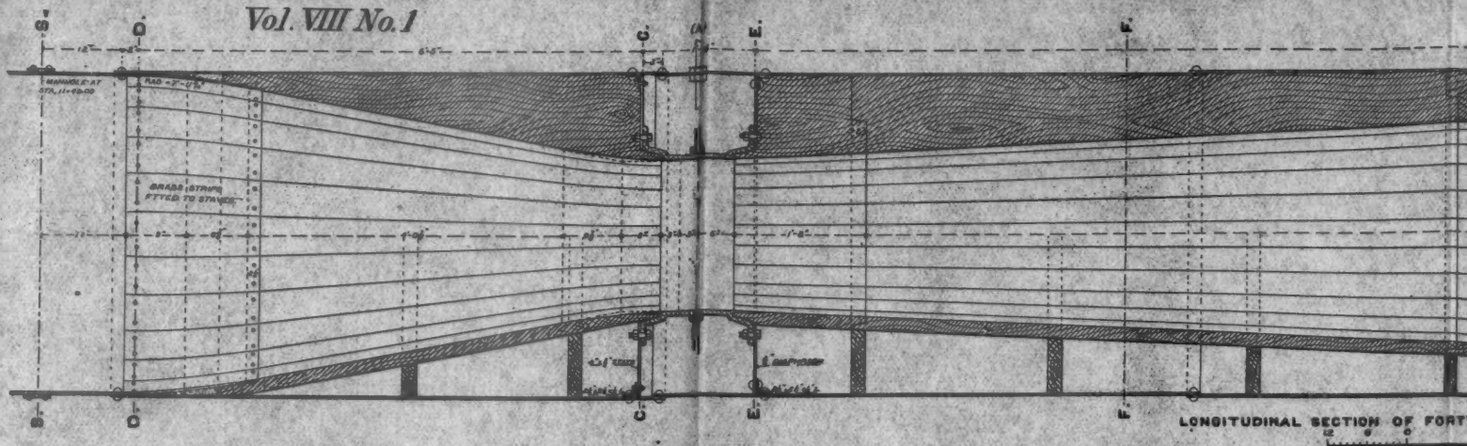


THE
EAST JERSEY WATER COMPANY

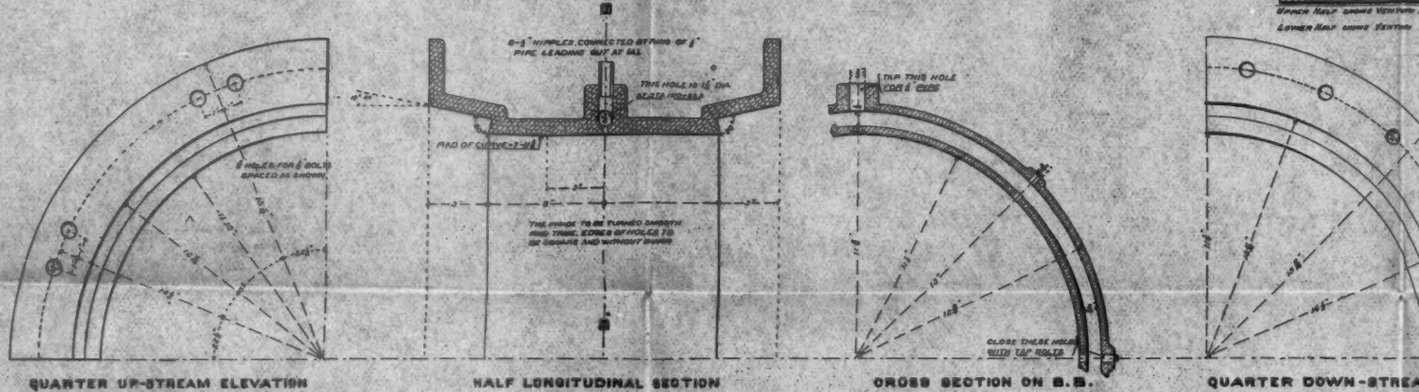
CONDUIT APPURTENANCES

DETAILS OF AIR VALVES

JUNE 1892



LONGITUDINAL SECTION OF FORT



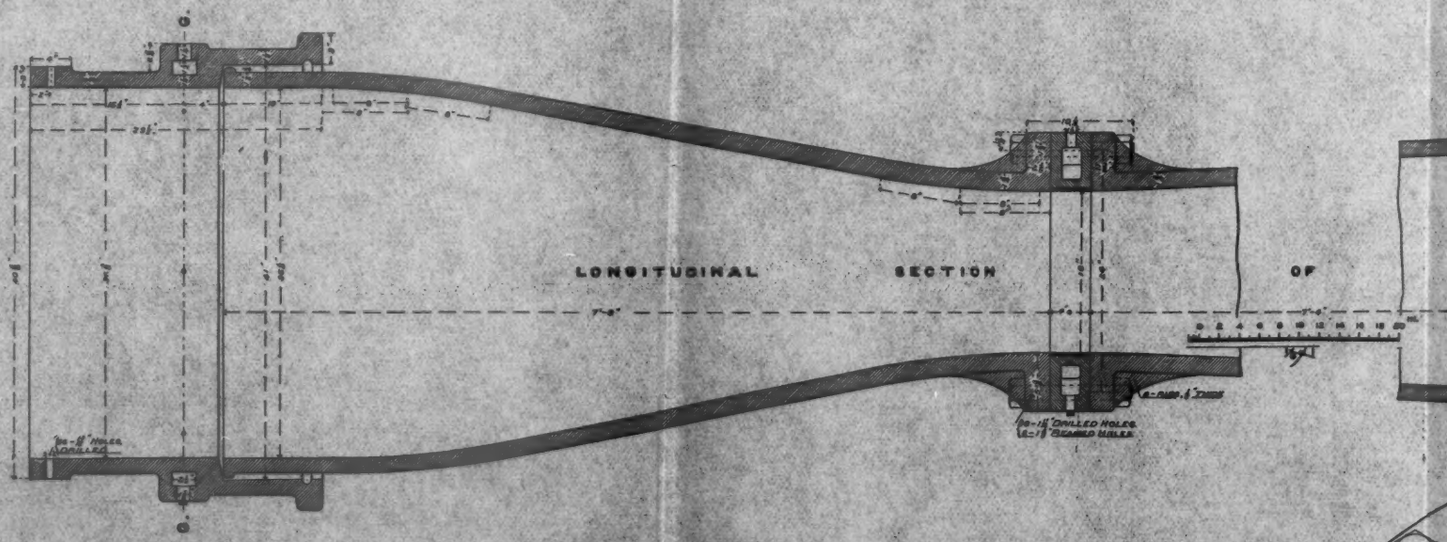
QUARTER UP-STREAM ELEVATION

HALF LONGITUDINAL SECTION

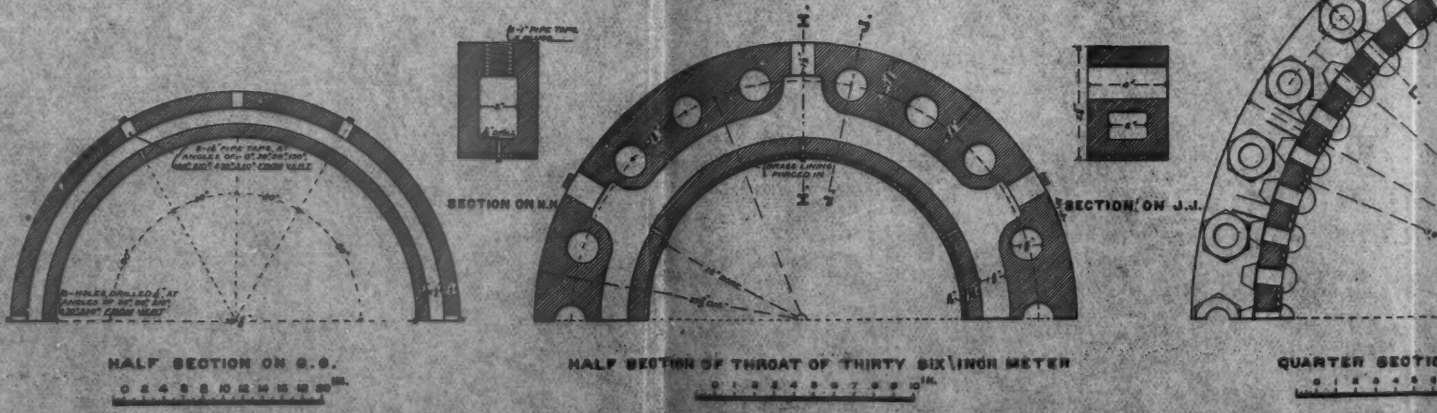
CROSS SECTION ON B.B.

QUARTER DOWN-STREA

THROAT OF FORTY EIGHT INCH VENTURI



LONGITUDINAL SECTION OF



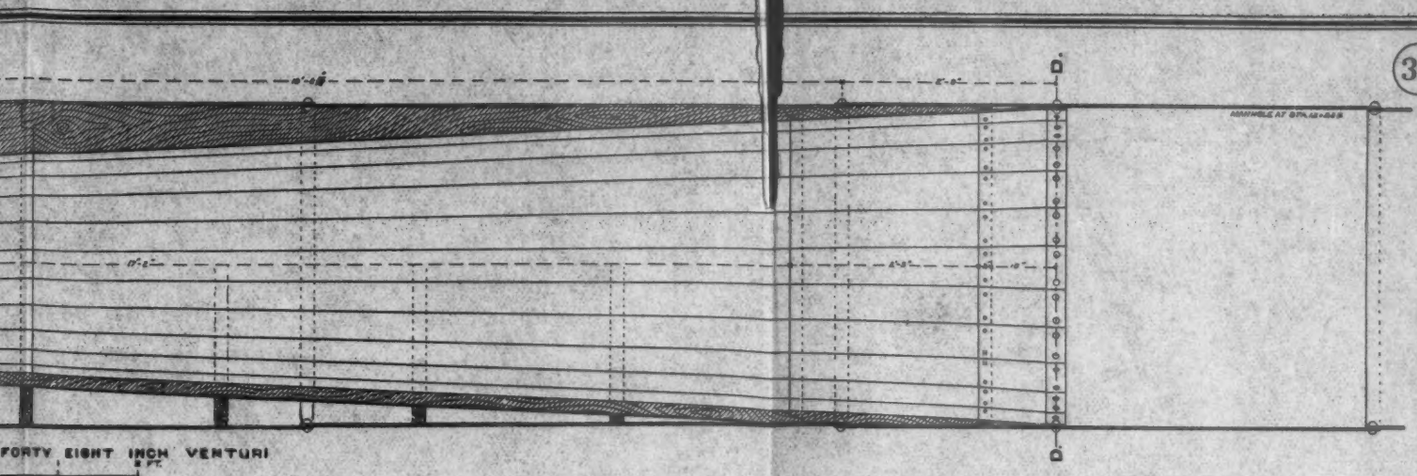
SECTION ON H.H.

SECTION ON J.J.

HALF SECTION ON G.G.

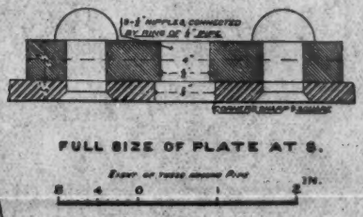
HALF SECTION OF THROAT OF THIRTY SIX INCH METER

QUARTER SECTI

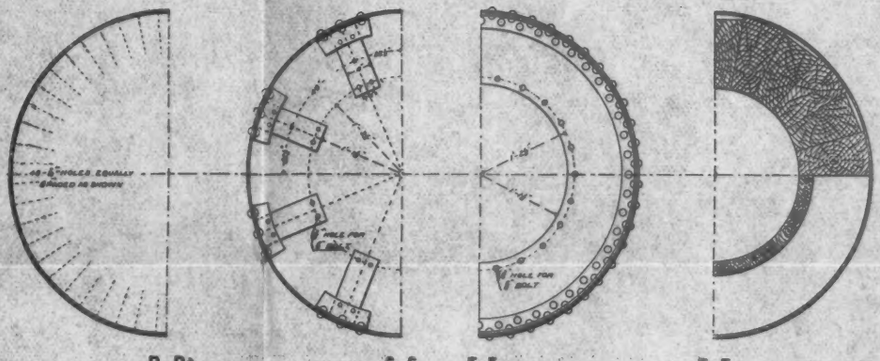


FORTY EIGHT INCH VENTURI

UPSTREAM ELEVATION

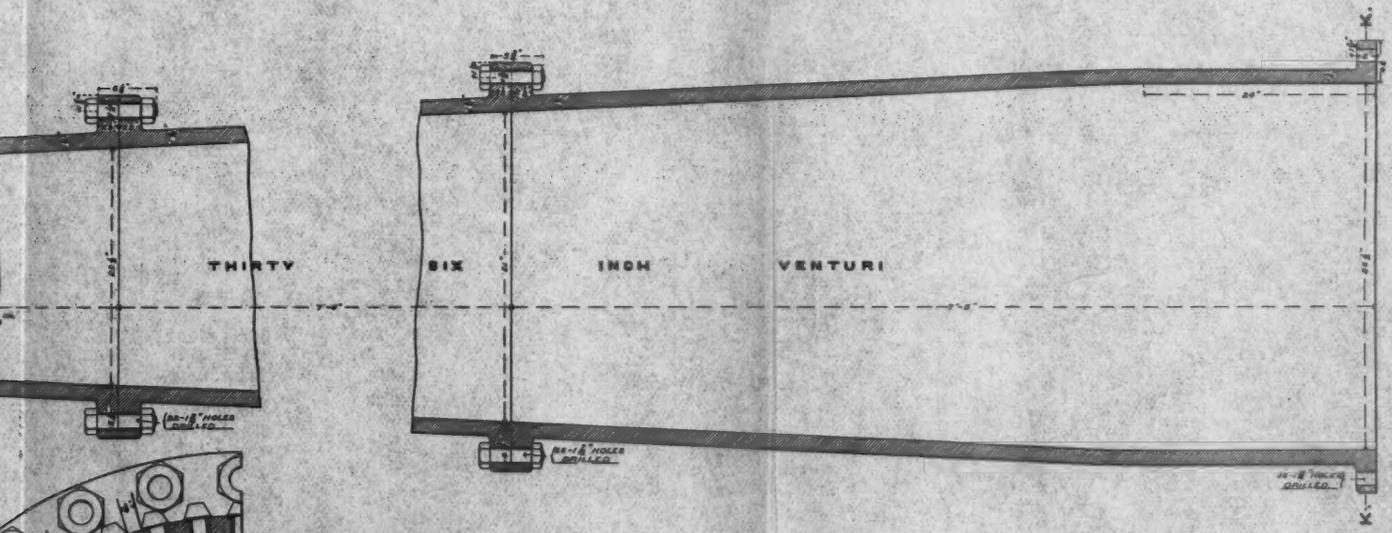


FULL SIZE OF PLATE AT S.



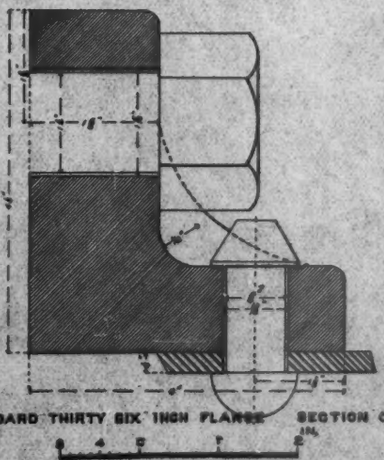
D. D₁ C.C. E.E. F.F.

HALF SECTIONS



THIRTY SIX INCH VENTURI

SECTION ON K.K.

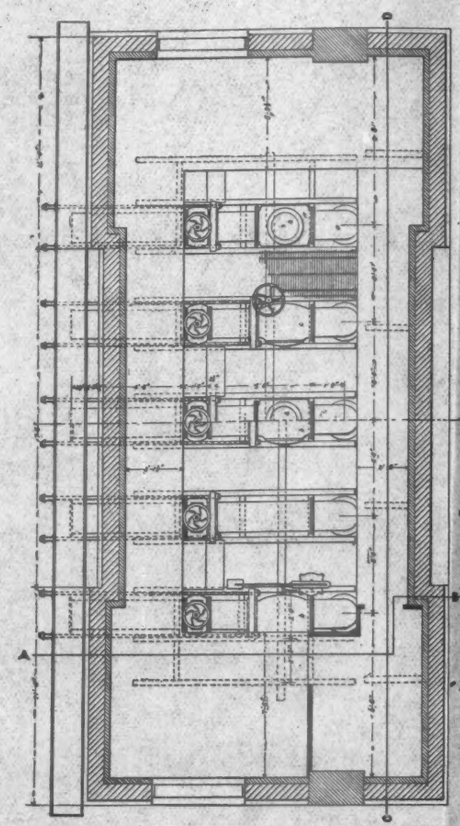


STANDARD THIRTY SIX INCH FLANGE SECTION ON L.L.

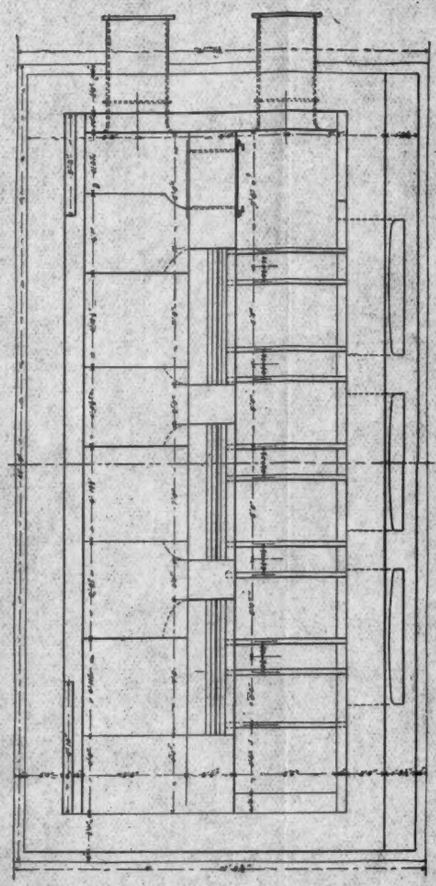
THE EAST JERSEY WATER COMPANY

VENTURI WATER METER

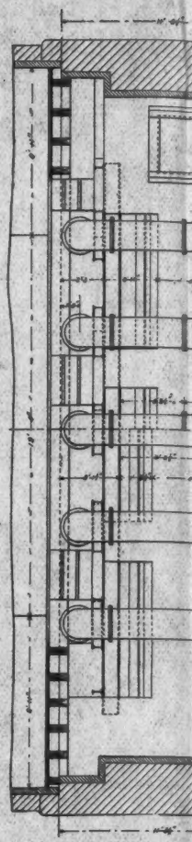
OCT. 1892

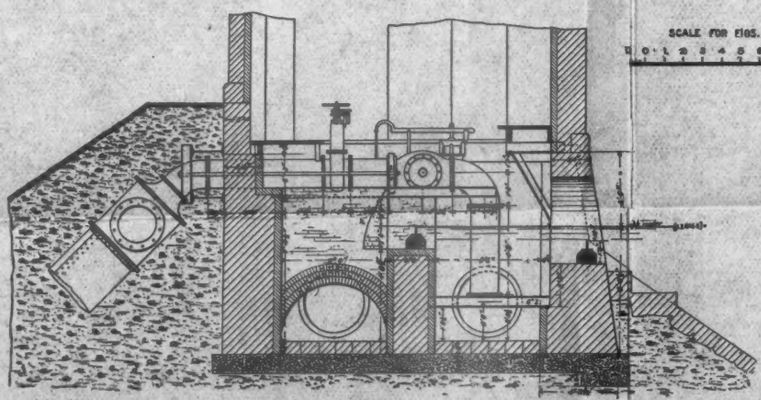


HALF 36 GR. AVE. GATE HOUSE PLAN. HALF BELLEVILLE GATE-HOUSE
Note:- In Plan Regulator & Weir Regulator are shown opposite and not as built.
FIG. 1.



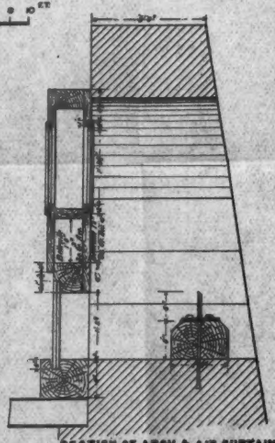
PLAN WITH FLOOR AND PIPES REMOVED
FIG. 2.



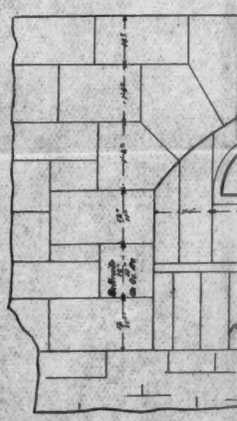


SECTION ON LINE A B - 36 GR. AVE. GATE HOUSE
FIG. 5.

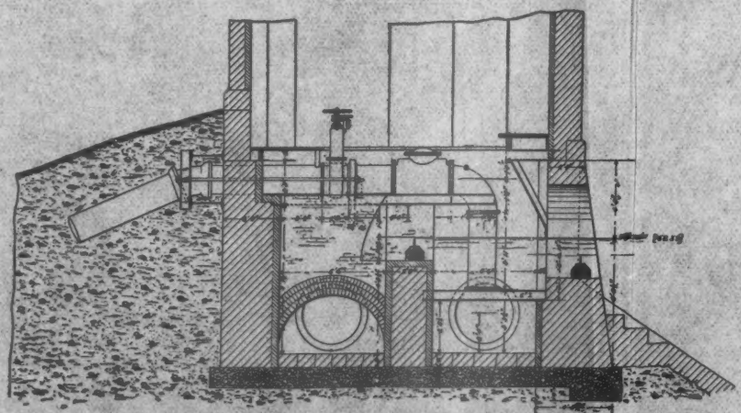
SCALE FOR FIGS. 1 TO 5.



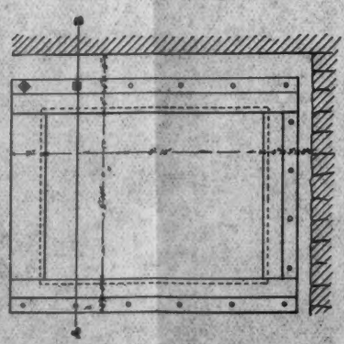
SECTION OF ARCH & AIR CURTAIN
FIG. 7.



ELEVATION O

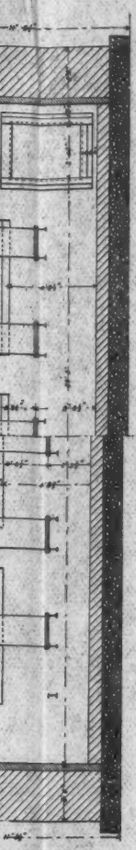


SECTION ON LINE A B - BELLEVILLE GATE HOUSE
FIG. 6.

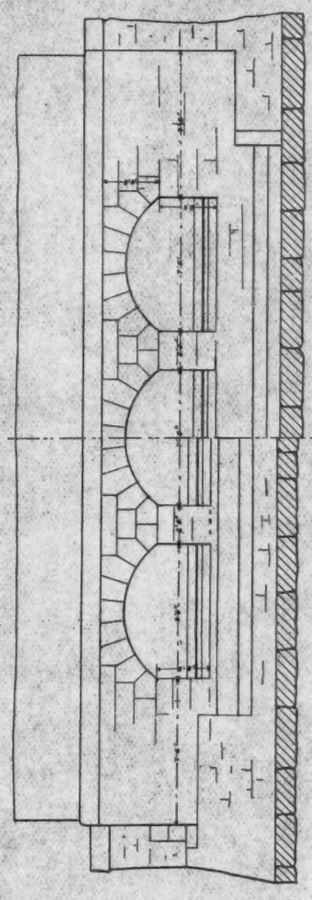


SPECIAL CASTING NO. 1
FIG. 8.

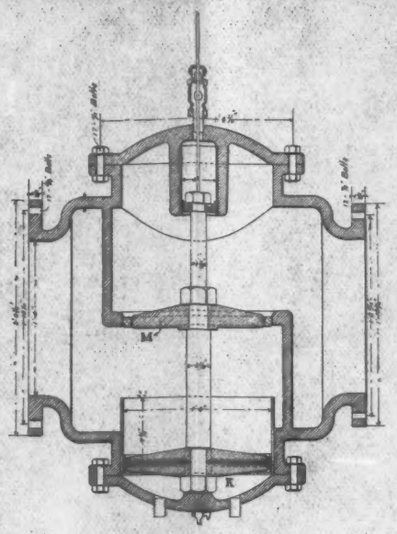
SCALE FOR FIGS. 7 TO 11.



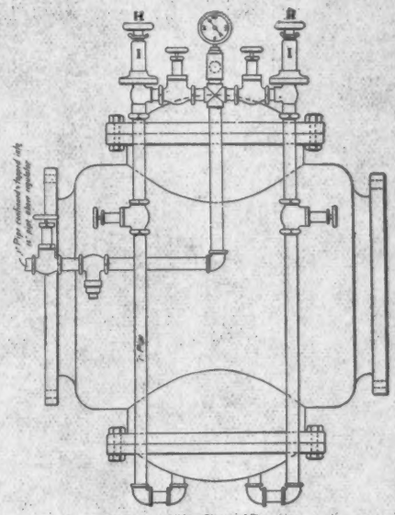
SECTION ON LINE C D
FIG. 9.



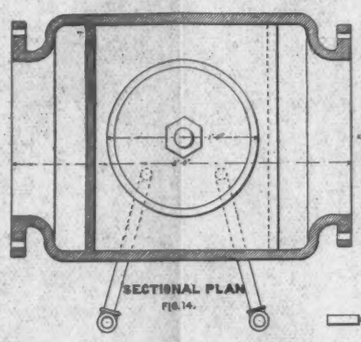
ELEVATION OF RESERVOIR FRONT
FIG. 9.



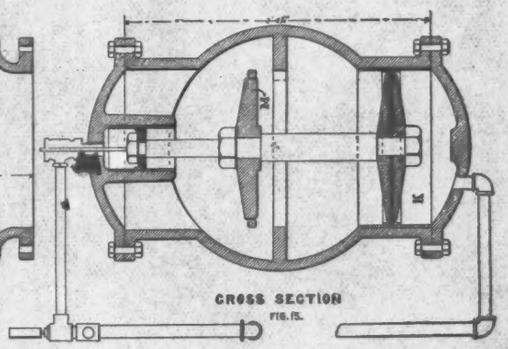
LONGITUDINAL SECTION.
FIG. 12.



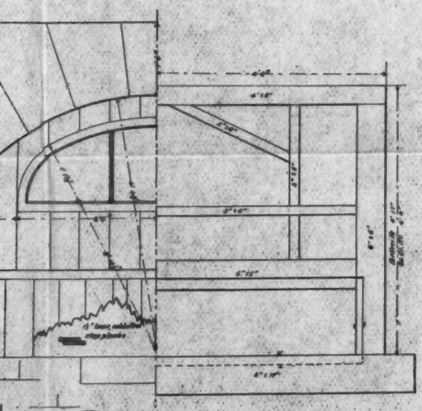
ELEVATION
FIG. 13.



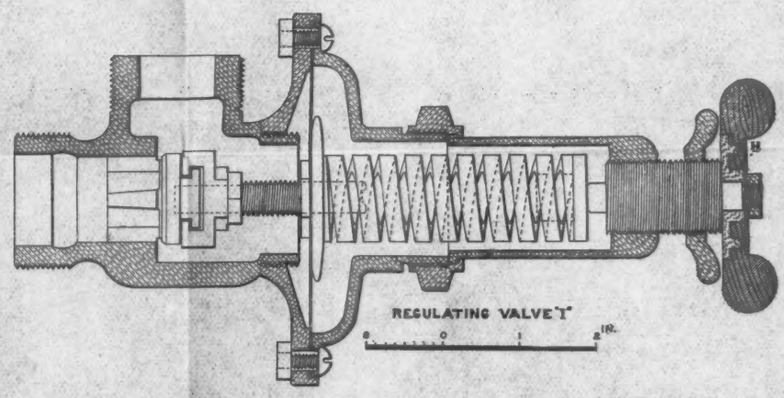
SECTIONAL PLAN
FIG. 14.



CROSS SECTION
FIG. 15.



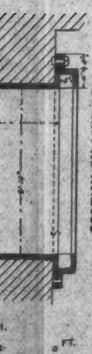
TION OF ARCH & AIR CURTAIN-WEIR REMOVED
FIG. 8.



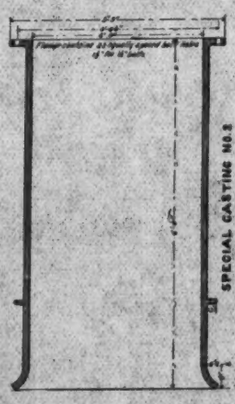
REGULATING VALVE 'T'

FOSS VALVE CO. PRESSURE REGULATOR

SCALE FOR FIGS. 12, TO 15.

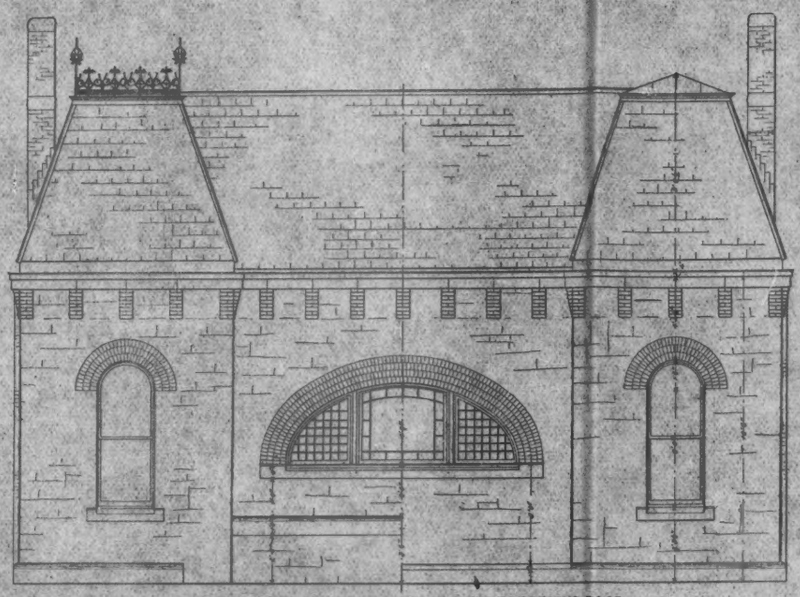


SECTION ON LINE A B
FIG. 10.

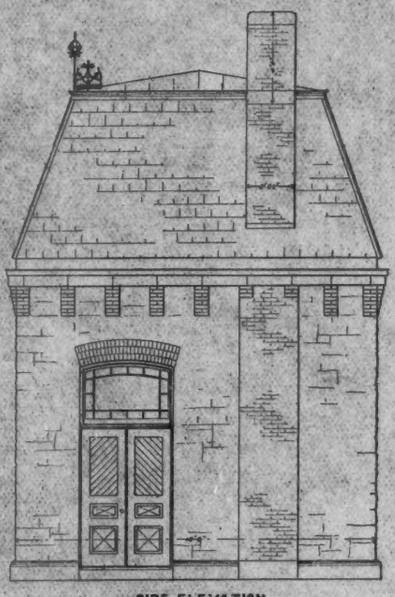


SPECIAL CASTING NO. 8
FIG. 11.

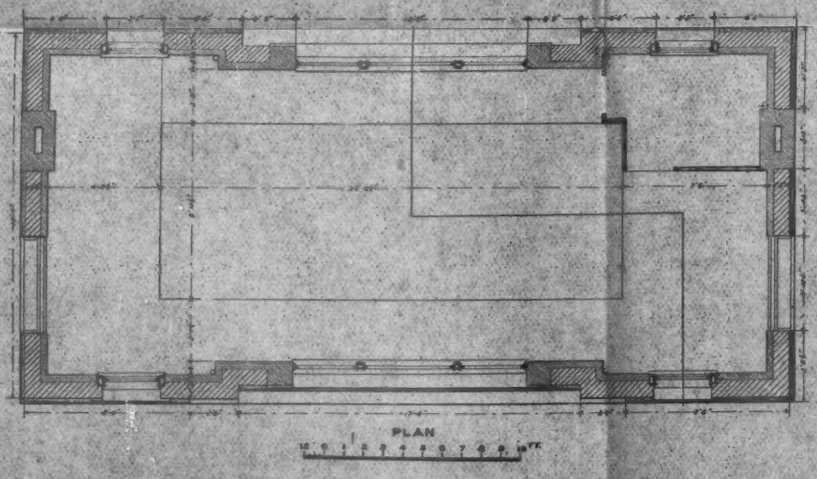
THE
EAST JERSEY WATER COMPANY
SUBSTRUCTURE OF GATE HOUSES
AT
NEWARK RESERVOIRS
NOVEMBER 1892



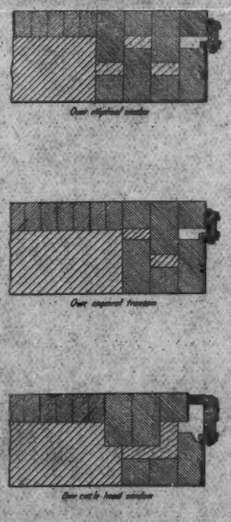
HALF STREET FACE-ELEVATION-HALF RESERVOIR FACE



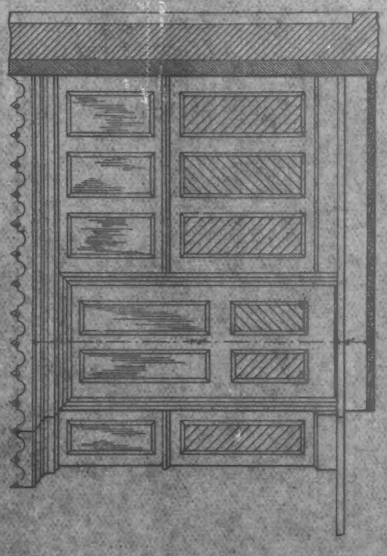
SIDE ELEVATION



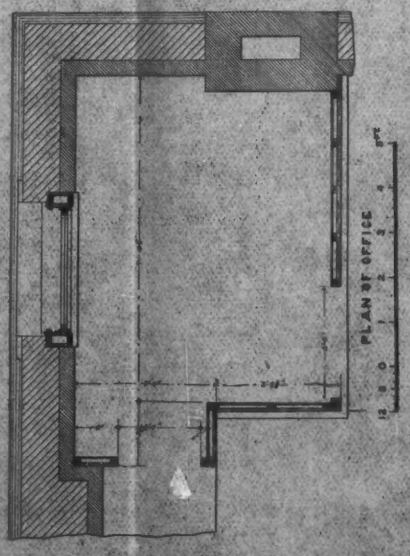
PLAN



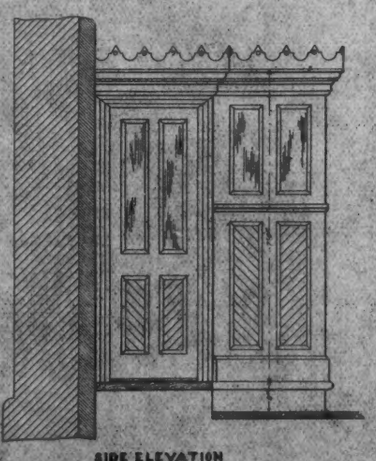
SECTIONS OF ARCHES



FRONT ELEVATION



PLAN OF OFFICE



SIDE ELEVATION

CROSS SECTION

THE

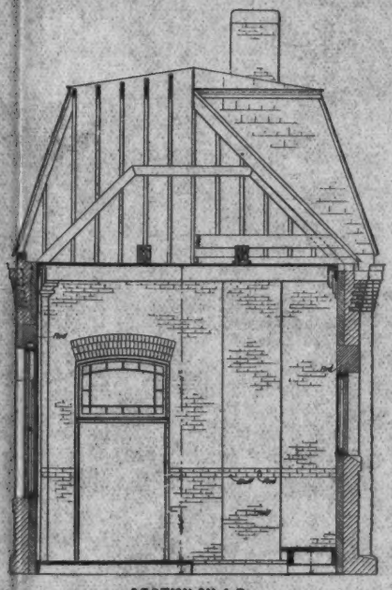
EAST JERSEY WATER COMPANY

SUPERSTRUCTURE OF GATE HOUSES

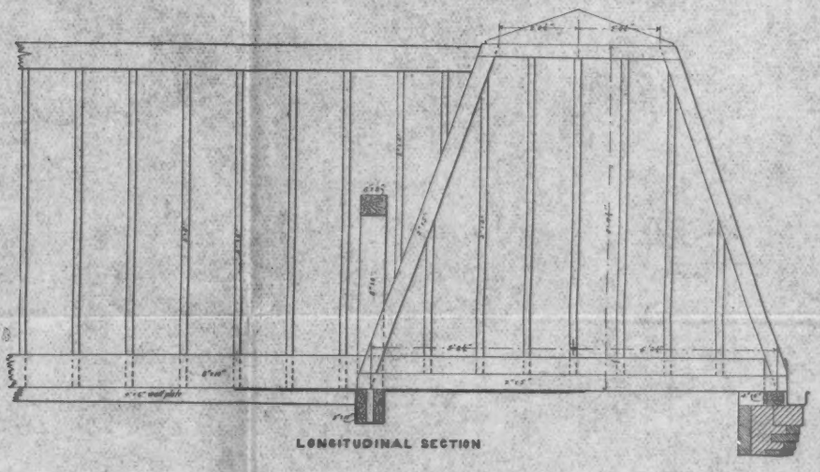
AT

NEWARK RESERVOIRS

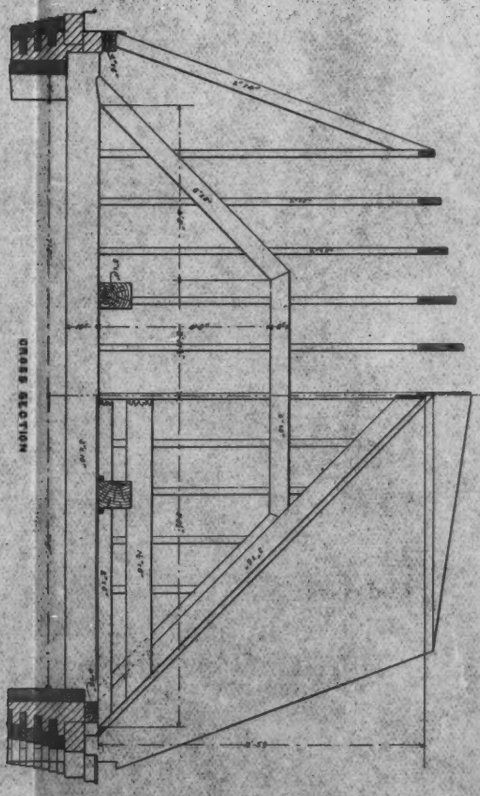
OCTOBER 1892



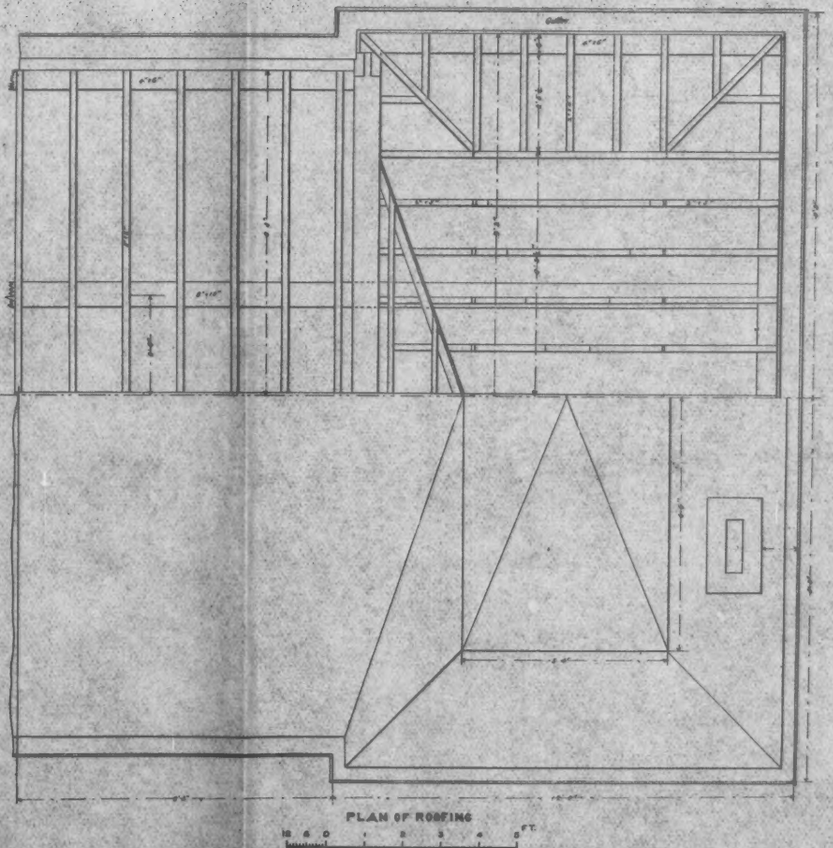
SECTION ON A B



LONGITUDINAL SECTION



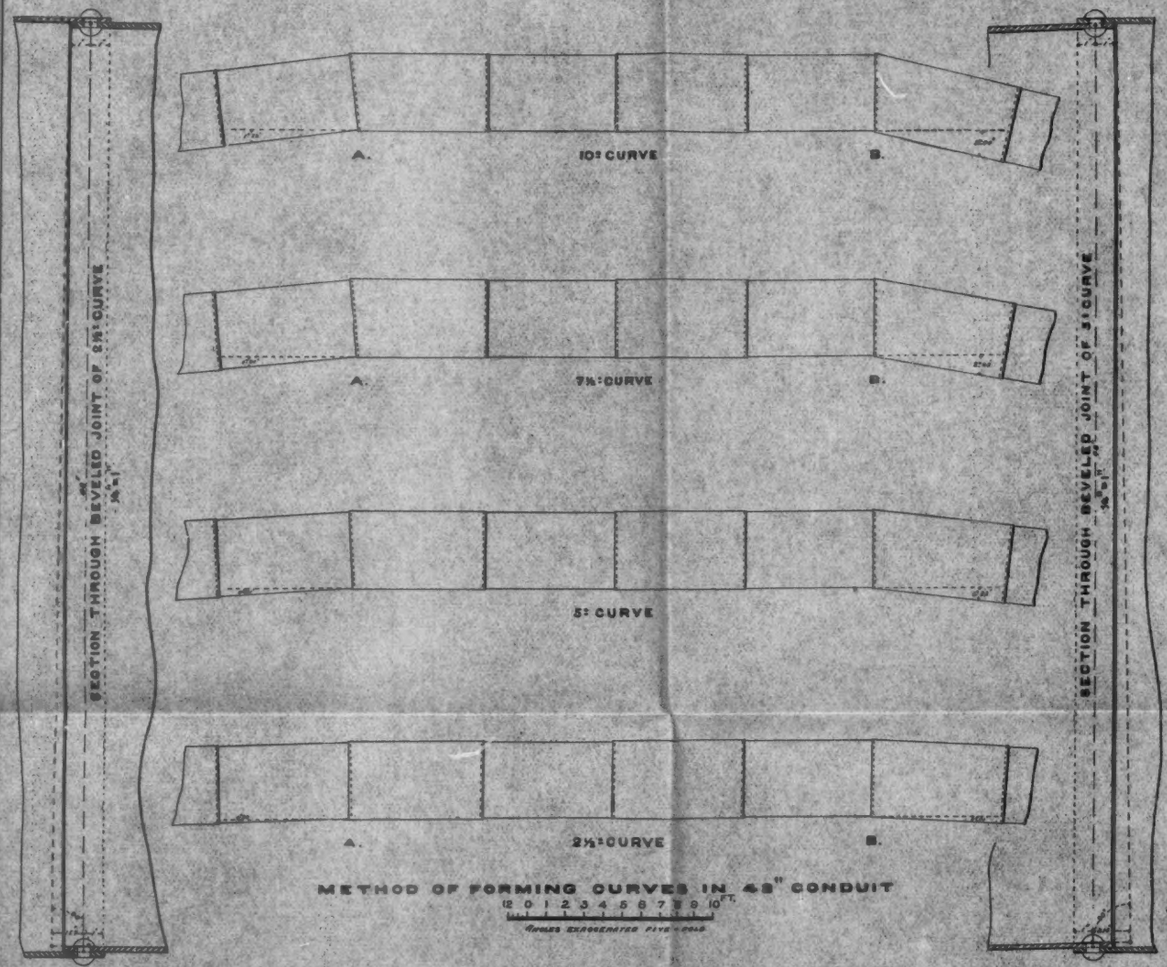
CROSS SECTION



PLAN OF ROOFING

10 6 0 1 2 3 4 5 FT.

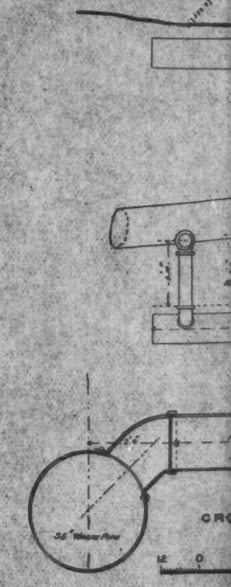
J.M.E.H.

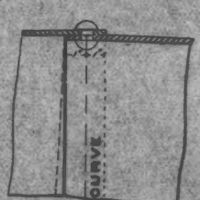


METHOD OF FORMING CURVES IN 48" CONDUIT

2 0 1 2 3 4 5 6 7 8 9 10 FT.

ANGLES EXAGGERATED FIVE-FOLD





SECTION THROUGH BEVELED JOINT OF 10° CURVE

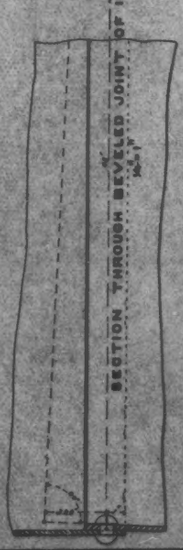


TABLE SHOWING METHOD OF FORMING CURVES IN 48 INCH CONDUIT

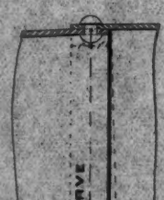
Degree of Curve	Radius	Length of Chord	at B.C. & E.C. (A) Angle between Chord & Tangent	Offset in 100'	in the Curve (B) Angle between Chords	Offset in 100'
10°	572.9	100 feet	2° 52'	1.75"	2° 00"	3.50"
7½°	764.8	" "	1° 01'	0.86"	2° 02"	1.75"
5°	1146.3	" "	0° 51'	0.43"	1° 43"	1.75"
2½°	2292.6	" "	0° 26'	0.22"	0° 51"	0.43"

Station of B. C.	Station of E. C.	Radius	Total Angle	Length of Chords	No. of Chords in Curve	at B.C. & E.C. Angle between Chord & Tan	at B.C. & E.C. Offset in 100'	in the Curve Angle between Chords	in the Curve Offset in 100'
1113+00.3	1117+21.8	95.5	19° 03'	6.09	4	3° 10"	1.05"	0° 29"	0.21"
1161+00.3	1167+29.2	95.5	23° 08"	6.09	6	3° 10"	1.05"	0° 29"	0.21"

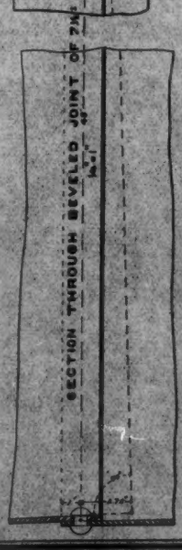
NOTE.—VERTICAL CURVES ARE MADE IN THE FIELD BY BENDING JOINTS, CUT TO SUIT THE ANGLE

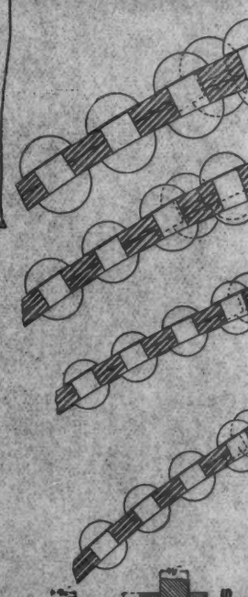
TABLE SHOWING METHOD OF FORMING CURVES AND ANGLES IN 36 INCH CONDUIT

Station of B. C.	Station of E. C.	Station of Intersection Point	Radius	Total Angle	Length of Chords	No. of Chords in Curve	at B.C. & E.C. Angle between Chord & Tan	at B.C. & E.C. Offset in 30 inches	in the Curve Angle between Chords	in the Curve Offset in 30 inches
1121+77.6	1127+82.7		72.8°	86°00"	6.05	6	2°15"	1.58"	0°30"	0.79"
		1123+77.8		43°00"						
		1125+92.3		21°50"						
		1129+82.2		21°00"						
1170+10.0	1176+03.0		82.6°	63°00"	6.01	10	2°10"	1.46"	0°29"	2.92"
1180+18.6	1186+20.5		82.6°	63°00"	6.01	10	2°10"	1.46"	0°29"	2.92"
1210+18.0	1216+24.1		82.6°	21°00"	6.00"		2°00"	1.35"	0°29"	2.70"
		1213+50.6		21°00"						
1216+24.1	1218+30.6		60.8°	20°00"	6.05"	10	3°00"	1.79"	0°36"	3.58"
		1220+71.5		43°00"						
		1223+73.0		21°00"						
1316+06.6	1319+30.2		72.8°	76°00"	6.55	10	2°30"	1.62"	0°33"	3.25"
1319+36.2	1324+36.2		72.8°	70°00"	6.55	10	2°30"	1.62"	0°33"	3.25"
1332+06.2	1336+42.2		60.8°	46°00"	6.10	10	3°00"	1.86"	0°36"	3.72"
1339+28.9	1345+00.0		82.6°	29°20"	6.06	6	2°10"	1.50"	0°29"	2.99"
1348+00.0	1351+00.3		82.6°	21°00"	6.10	10	2°15"	1.58"	0°30"	3.16"
		1353+32.8		21°00"						



SECTION THROUGH BEVELED JOINT OF 2½° CURVE





SECTION OF DOUBLE LAP JOINTS

PROFILE
1/8" = 1'

OVERFLOW WASTE AT POMPTON NOTCH

0 2 4 6 8 10 12 14 16 18 20 FT

PLAN
1/8" = 1'

36" WASTE PIPE

CROSS SECTION
1/4" = 1'

0 1 2 3 4 5 FT.

48" CONDUIT

FLANGE (O.)

12 6 0 1 FT

3/8" PLATE 48" CONDUIT

5/16" PLATE 48" CONDUIT

1/4" PLATE 48" CONDUIT

1/4" PLATE 36" CONDUIT

SECTION OF CIRCULAR SEAMS

6 0 1 2 3 4 5 IN.

NOTE. SIDE SEAMS AND FIELD SEAMS MADE OUT OF TRENTON, ARE AS SHOWN.
RIVETS IN UPPER HALF OF FIELD SEAMS MADE IN TRENTON, WERE COUNTER SUNK
HEADS OF PLATE, IN LOWER HALF, COUNTER SUNK ARE OUTSIDE.

TABLE SHOWING METHOD OF RIVETING

Index	Description	Figure 1	Figure 2	Figure 3	Figure 4
Applicable to Longitudinal Seams	Nominal Size of Pipe	48	48	48	36
	Thickness of Plate	3/8	5/16	1/4	1/4
	Size of Large Sheets	120 3/4 x 120	120 3/4 x 120	120 3/4 x 120	113 3/4 x 120
	Size of Small Sheets	120 3/4 x 120	120 3/4 x 120	120 3/4 x 120	113 3/4 x 120
	Inside Diameter of Small Ring	47 5/8	47 7/8	47 7/8	35
	Inside Diameter of Large Ring	48	48	48	36 1/8
	Size of Rivets	7/8	7/8	7/8	7/8
	Size of Rivet Hole	15/16	15/16	15/16	15/16
	Width of Rivet Head	1 7/16	1 7/16	1 7/16	1 7/16
	Height of Rivet Head	9/16	5/8	9/16	9/16
Applicable to Circular Seams	Number of Rivets per Seam	168	168	126	126
	Circumference of Large Sheets	120 . 000	120 . 000	120 . 000	113 . 097
	Circumference of Small Sheets	119 . 804	119 . 804	119 . 804	112 . 902
	Rivet Pitch of Large Ring	2 . 810	2 . 810	2 . 810	2 . 827
	Rivet Pitch of Small Ring	2 . 806	2 . 806	2 . 806	2 . 826
	Distance from Centre of Rivet to Edge of Plate	1	1 1/16	1 1/16	1
	Lap of Sheets at Circular Seam	2	2 1/16	2 1/16	2
Applicable to Longitudinal Seams	Number of Rivets in First Row	60	60	60	60
	Number of Rivets in Second Row	59	60	59	59
	Total No. of Rivets Exclusive of Circular Seam	60	60	60	60
	Rivet Pitch of both Rows	2.377	2.721	3.125	2.979
	Distance between Rows	1 5/8	1 5/8	1 5/8	1 5/8
	Diagonal Pitch	1.897	1.996	2.001	1.927
	Distance from Pitch Line to Edge of Plate	1 5/16	1 5/16	1 5/16	1 5/16
	Lap of Sheets at Longitudinal Seam	3	3	3	3

SECTION OF DOUBLE LAP JOINTS

NOTE: THESE ARE USED AT CROSS OF TRENTON, MAHON, ARMOUR, AND ARE USED AT OTHER LONG SEAMS.

PLAN OF SEAMS

12 6 0 FT.

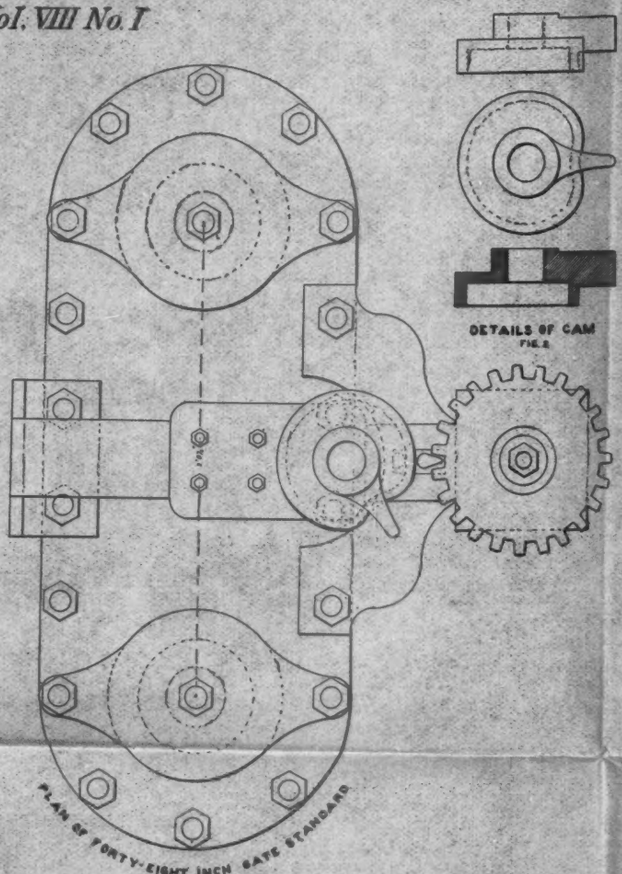
THE

EAST JERSEY WATER COMPANY

CONDUIT DETAILS

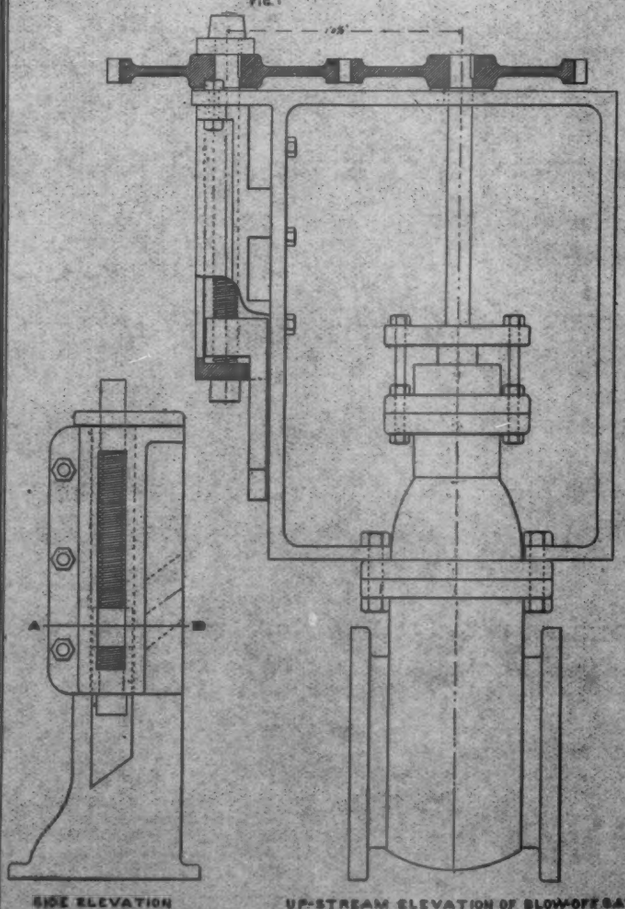
NOVEMBER 1892

M.K.W.A.N.S.



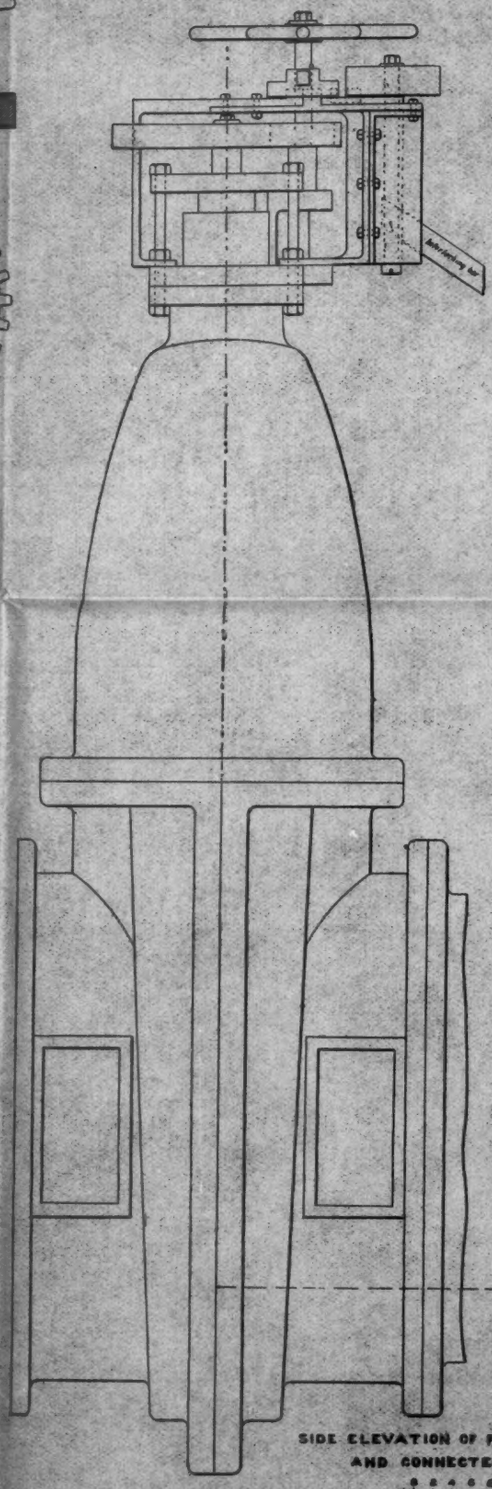
PLAN OF FORTY-EIGHT INCH GATE STANDARD
FIG. 1

DETAILS OF CAM
FIG. 2

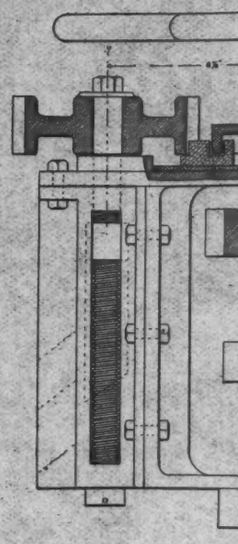


SIDE ELEVATION
FIG. 3

UP-STREAM ELEVATION OF BLOW-OFF GATE
FIG. 4

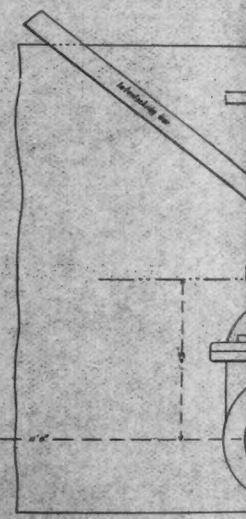


SIDE ELEVATION OF FORTY-EIGHT INCH GATE
AND CONNECTED BLOW-OFF GATE



SIDE ELEVATION

LOCKING PIN
FIG. 6



DETAILS OF INTERLOCKING BLOW-OFF APPARATUS

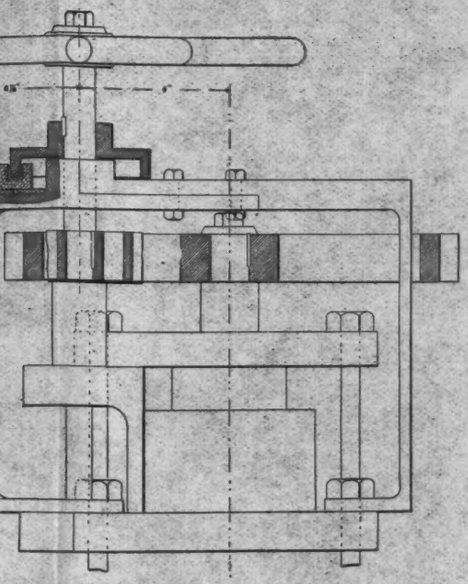
THE

EAST JERSEY WATER COMPANY

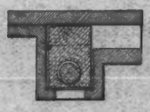
CONDUIT APPURTENANCES

DECEMBER 1892

SCALE FOR FIGS. 1 TO 6

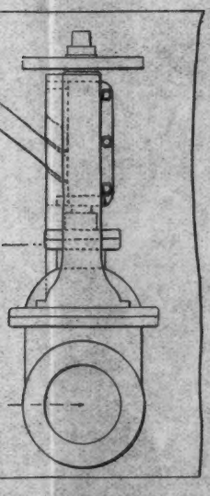


TION AT FORTY-EIGHT INCH GATE STANDARD
FIG. 5



SECTION ON AB

PIN



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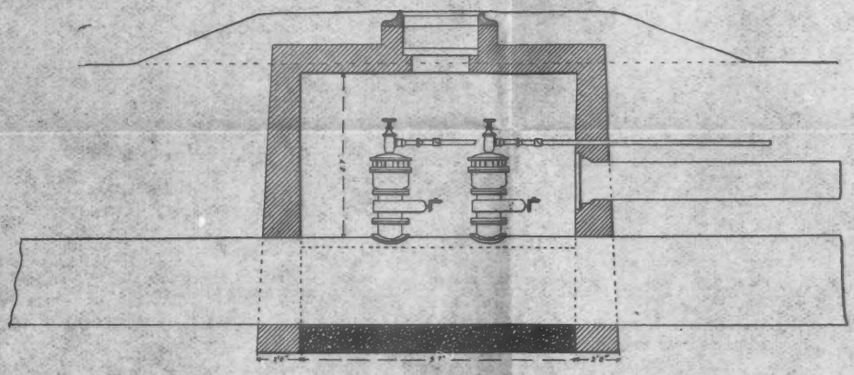
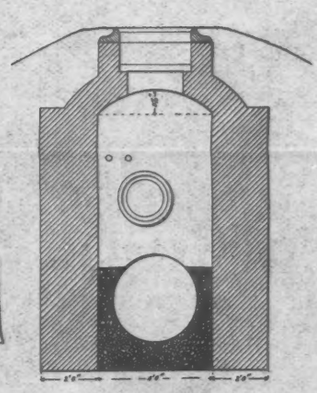


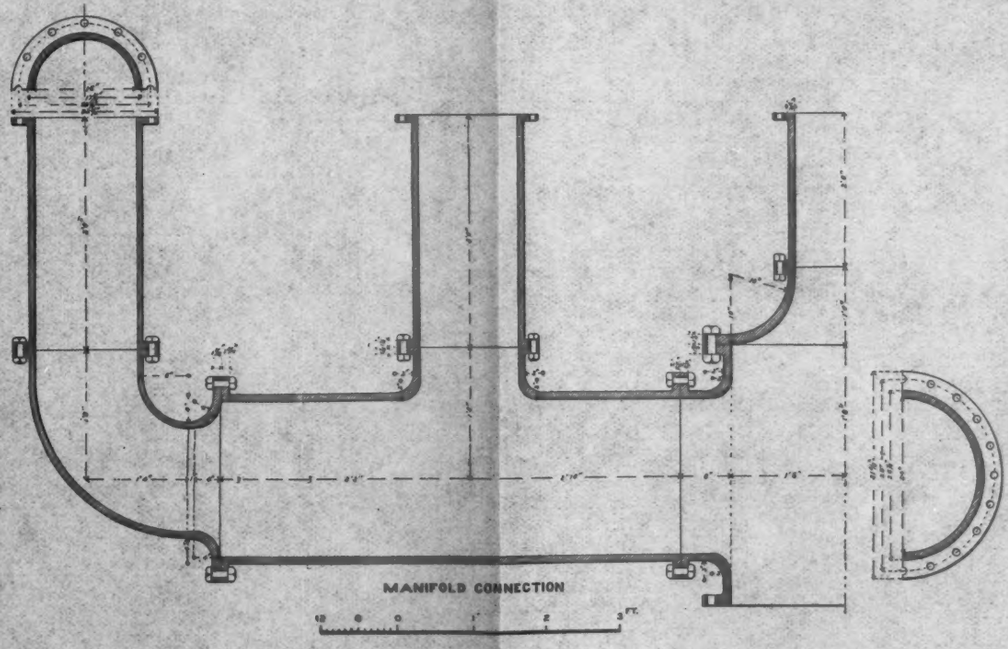
LONGITUDINAL SECTION



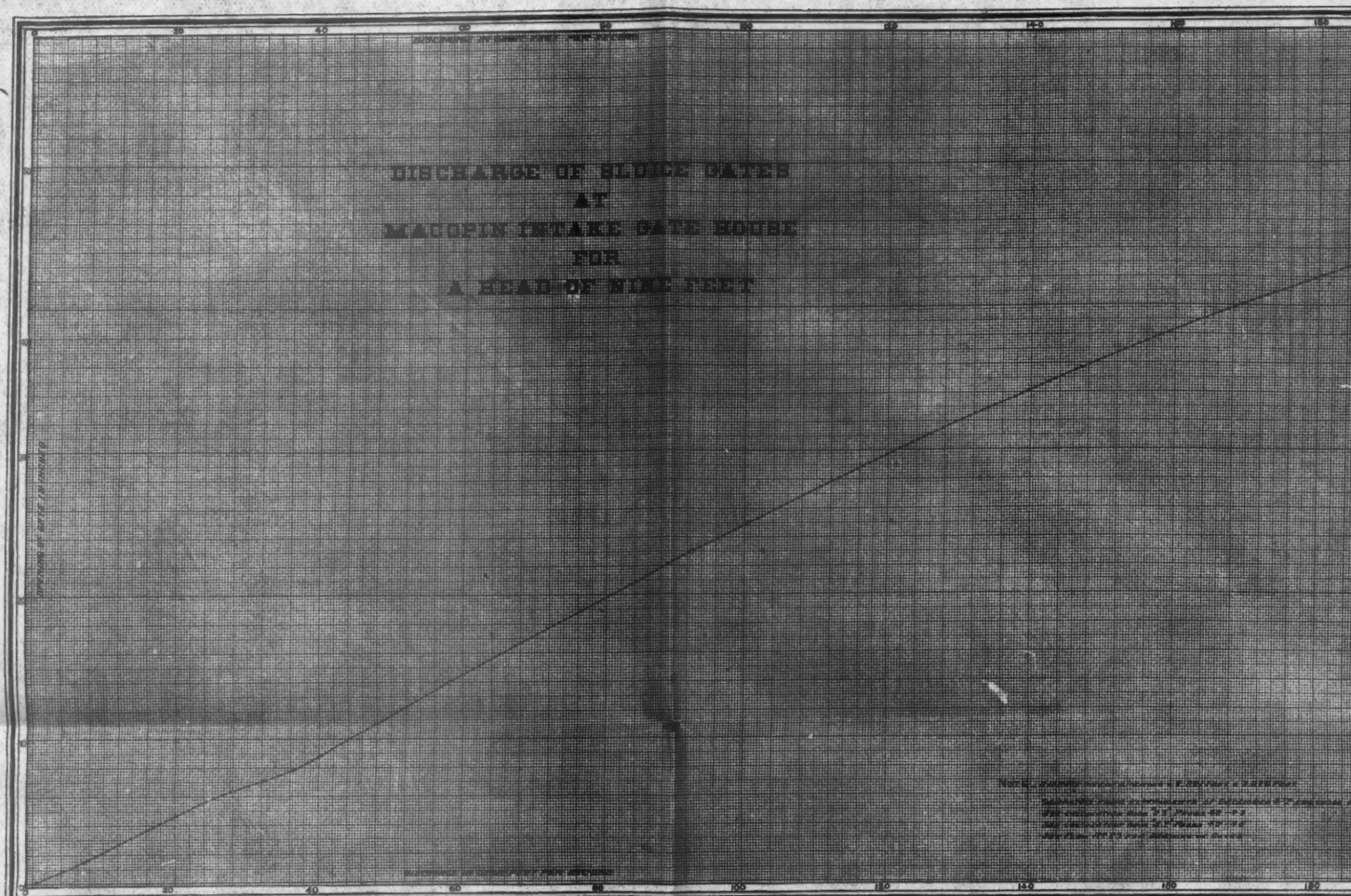
CROSS SECTION

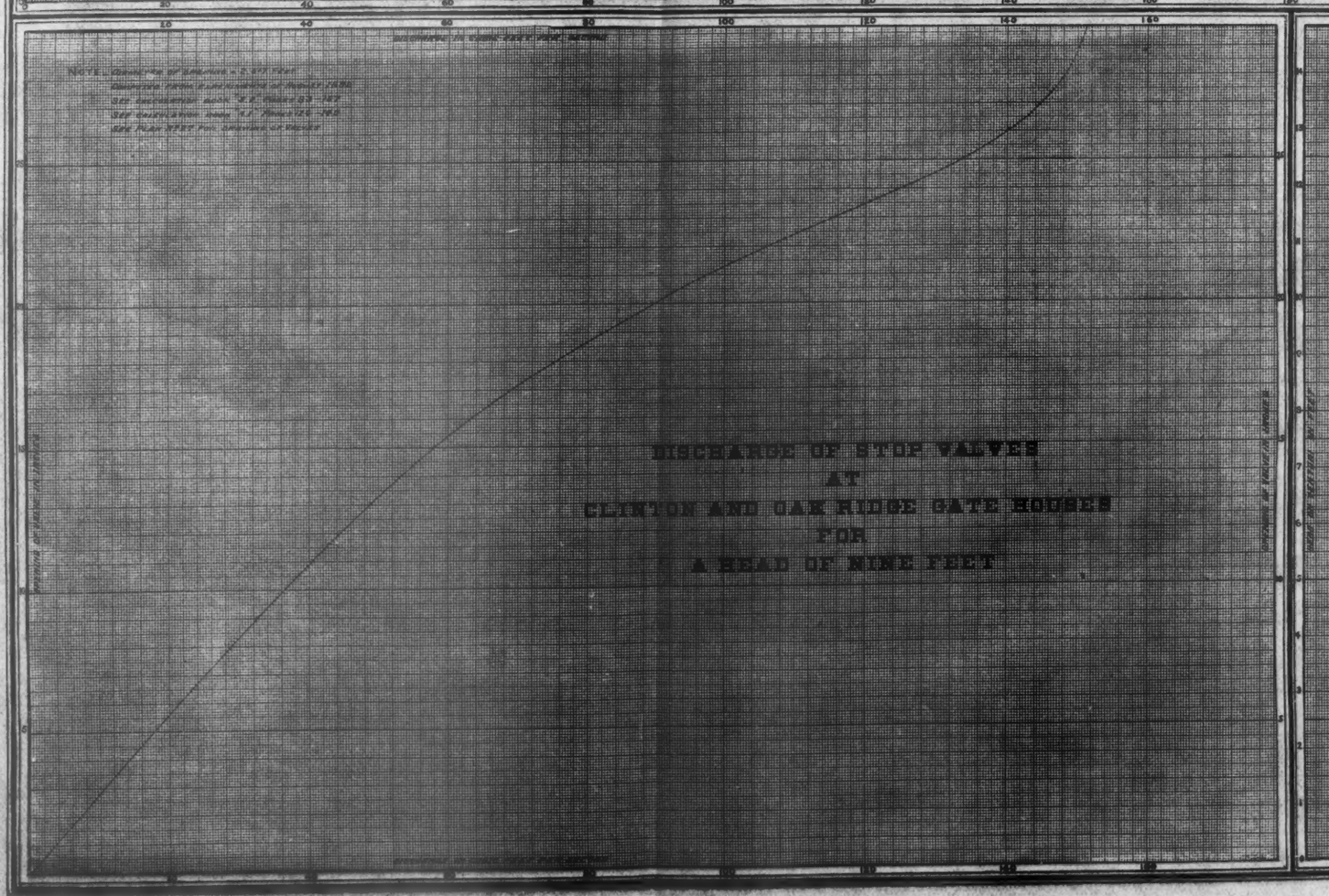
AIR VALVE VAULT

Note – Details shown are of vault at station , vaults on thirty-six inch conduit – Others are similar



MANIFOLD CONNECTION


DISCHARGE OF SLUICE GATES
AT
MACHEN INTAKE GATE HOUSE
FOR
A HEAD OF NINE FEET


DISCHARGE OF STOP VALVES
AT
CLINTON AND OAK RIDGE GATE HOUSES
FOR
A HEAD OF NINE FEET

THE

EAST JERSEY WATER COMPANY

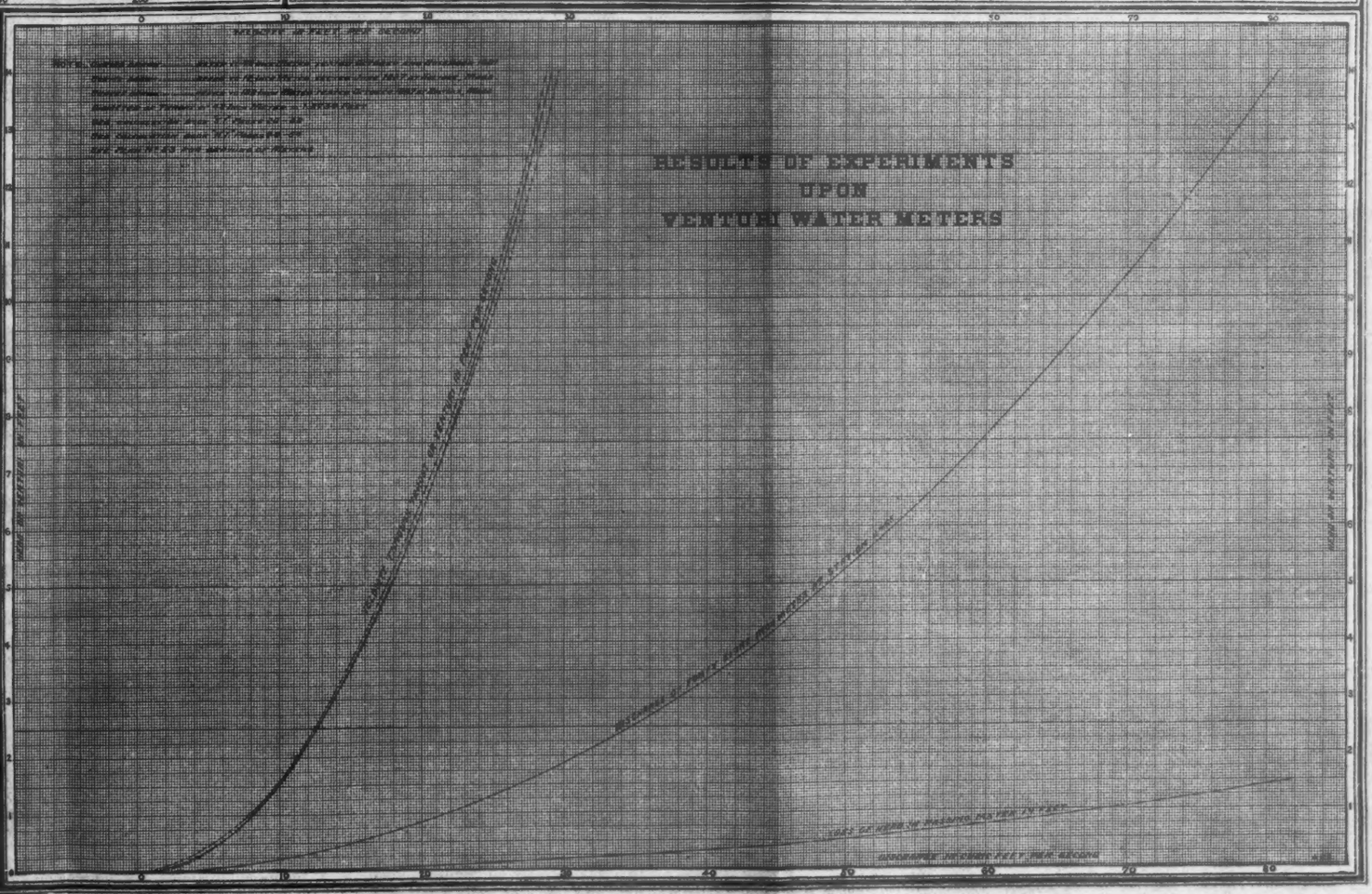
DISCHARGE DIAGRAMS

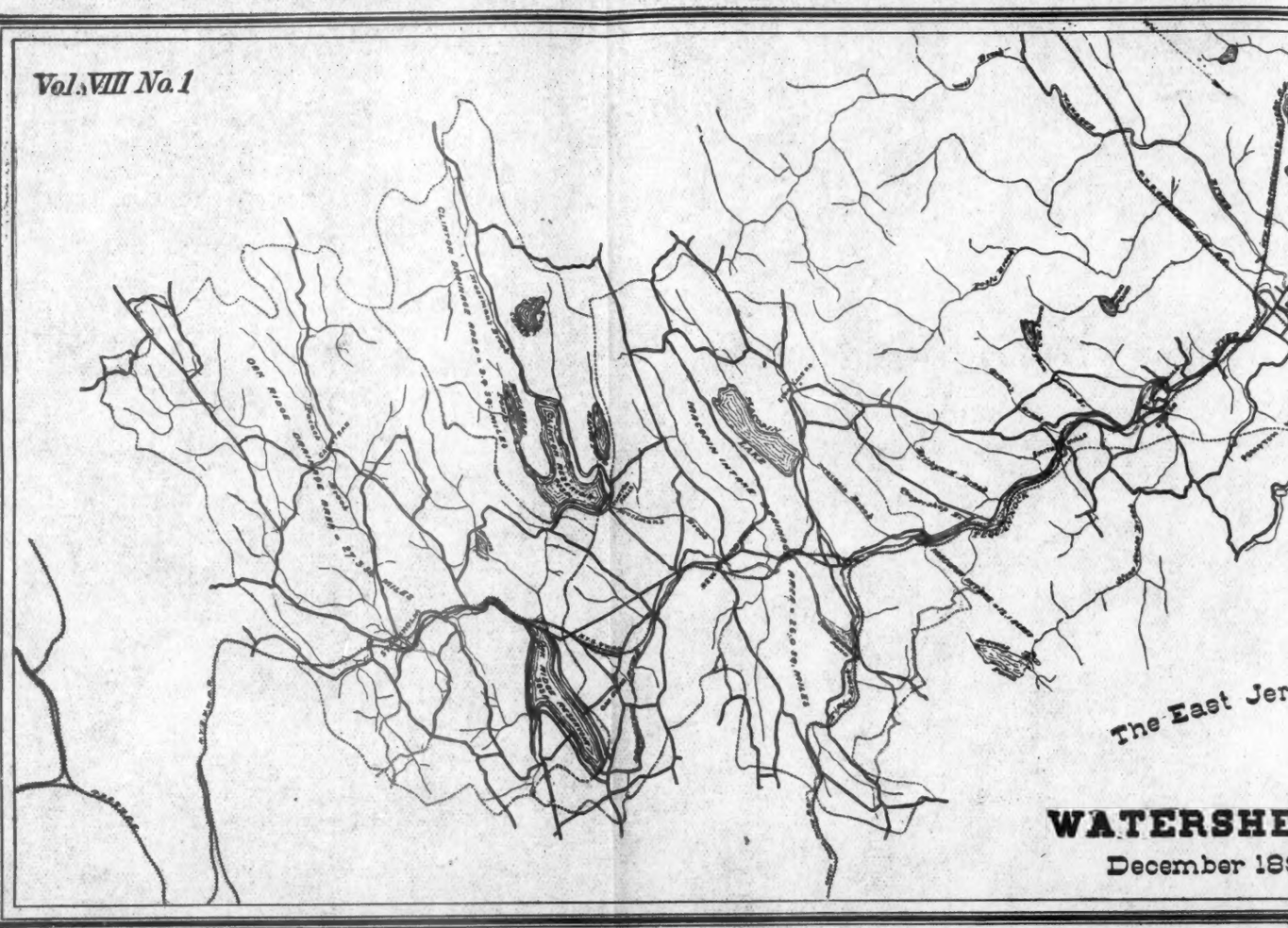
DECEMBER 1892

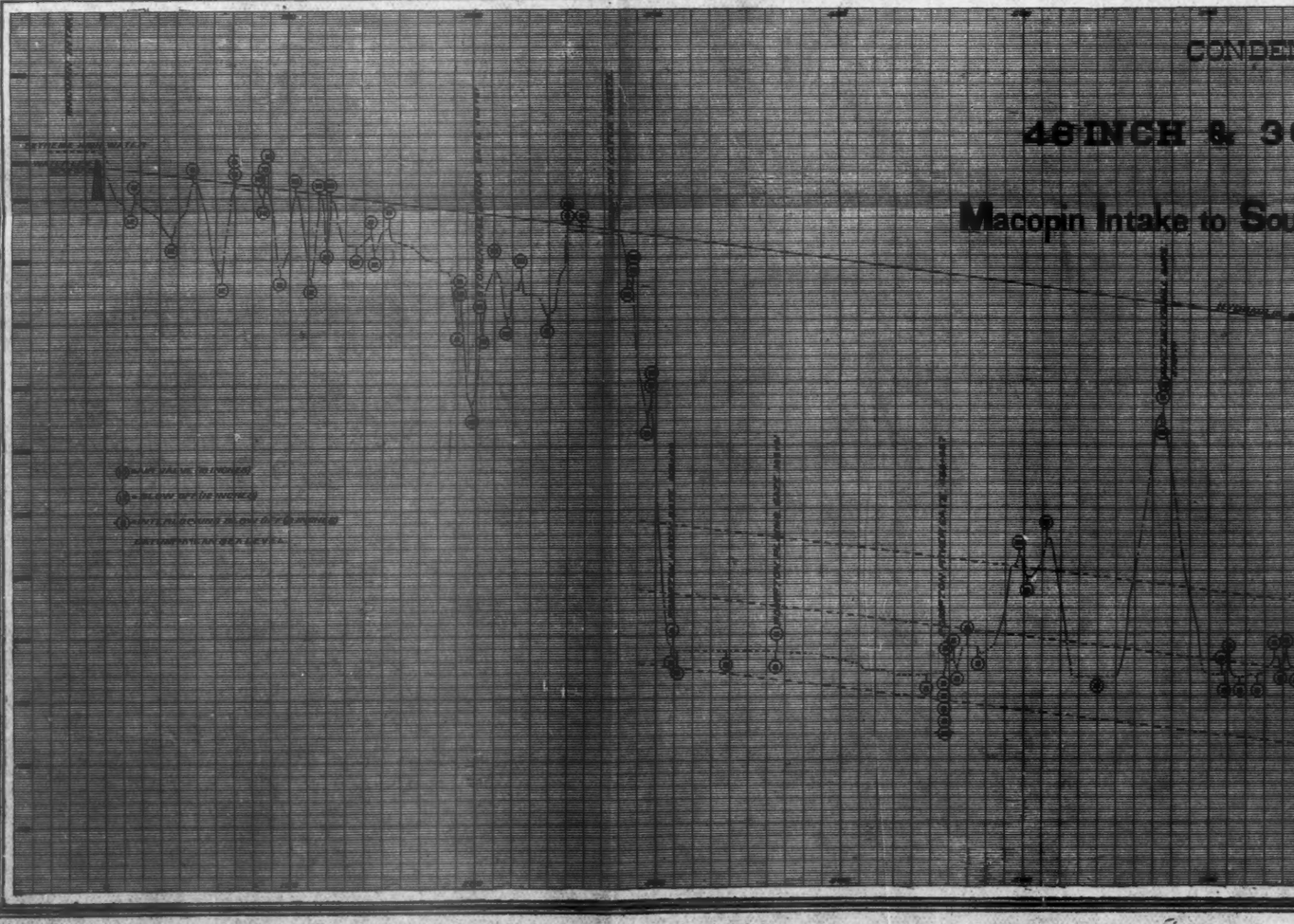
RESULTS OF EXPERIMENTS

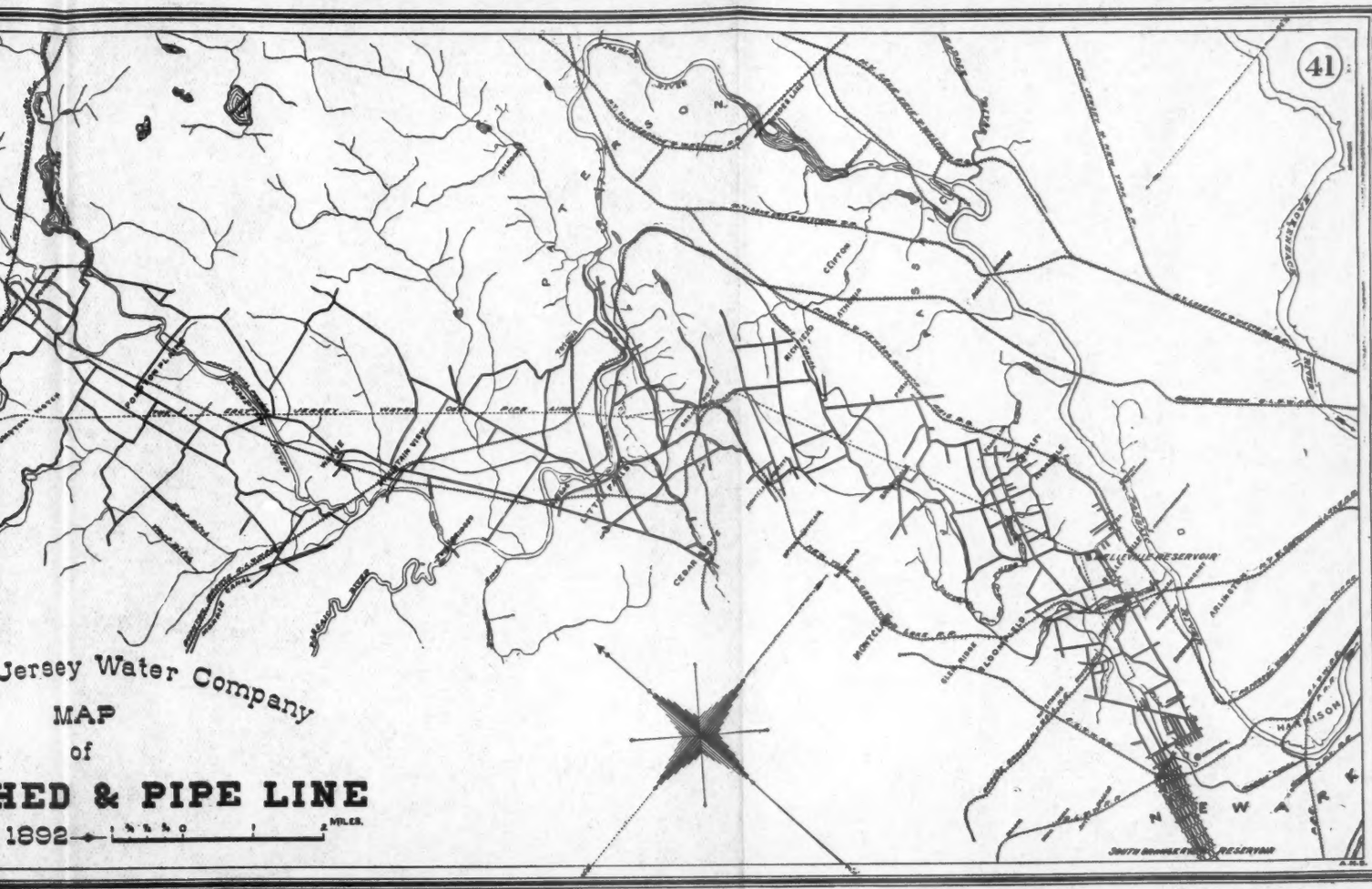
UPON

VENTURI WATER METERS

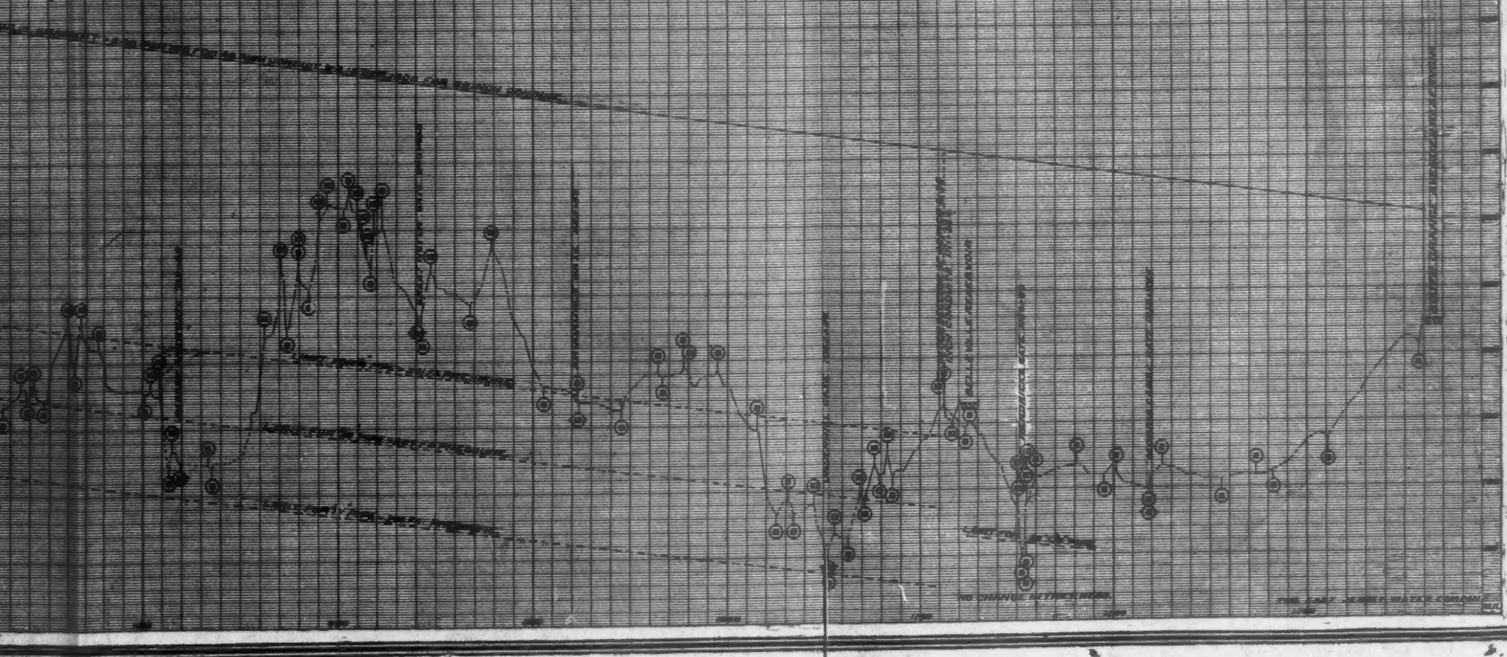



The East Jer
WATERSHE
December 18


CONDE
48 INCH & 3
Macopin Intake to So



DENSED PROFILE
of
36 INCH CONDUITS
from
South Orange Avenue Reservoir



hat. To illustrate the utility of such an inspection of hydraulic works, a list of the articles found in these 26 miles of pipe, all built under inspection, and supposed to contain nothing when the final inspection commenced, is here given:

1 cedar post.
2 brooms.
1 paint pot, and brush in it.
1 holding-on sledge.
1 dolley-bar and strap.
1 3-ft. piece of board.
1 2-ft. piece of plank.
1 18-in. piece of plank.
1 bottle.
3 washers.
1 round piece of steel.
1 rivet.
½ pail of iron scraps.
1 half-pint of steel clippings.
3 wooden wedges.
1 10-ft. piece of canvas.
3 6-ft. pieces of canvas.
2 3-ft. pieces of canvas.
2 small pieces of canvas.
1 pair of pants.
1 pair of suspenders.
1 pair of overalls.
½ dozen good-sized stones.
1 stone, size of your fist.
1 hat full of small stones.
½ dozen small stones.
1 pint of pebbles.
2 pieces of a glove.
1 half-bushel of clay.
1 bunch dried leaves.

Besides this, the inspectors found a rivet-hole without a rivet in it, in a shop seam. Two more such rivet-holes in field seams, and three 1¼-inch plug holes (used to drop the red-hot rivets into the pipe), similarly devoid of metal to stop them up, the inspectors did not find from the inside; though there was no difficulty in finding them from the outside after the water had been turned on.

The water first reached Belleville Reservoir January 12, having been allowed to fill the pipe by day only, and proceeding cautiously along the whole length. Also, drawing off and remedying defects as they were developed. February 15, the water first reached the South Orange-avenue Reservoir, having been delayed to await the completion of the high-service gate-house. The city of Newark has pumped no water for the consumption of either the low or the high service districts since April 26.

Hydraulic Experiments. — Among the illustrations will be found diagrams giving the results of such hydraulic experiments as have been made on the works to date. Others yet to be made may form the subject of a future communication.

Those now given comprise (1) the discharge of one of the head-gates, or sluices, at the Macopin Intake; (2) the discharge, and the loss of head occasioned by the 48-inch Venturi meter set in line of the pipe near Macopin Intake; (3) the discharge of one of the outlet gates of the Clinton reservoir.

The following table illustrates the action of the three principal parts, and of the whole, of the drainage area and of the reservoirs in supplying 50 million gallons daily. It is based on careful daily measurements of the natural flow of the river, being the flow of the river as it would have been at the Intake Dam, had there been no works constructed by the East Jersey Water Company, and on an assumed draft of 50 million gallons daily during the same time. It is the intention to continue these daily gaugings and records, as part of the duties of operating the works. If continued long enough, these tables will evidently present just as good a measure of the capabilities of the drainage area in question as any tables of rainfall, with their annually and monthly varying appurtenant coefficients of yield, can possibly present.

Flow of the Pequannock River by weeks, and Volume in Store in each Reservoir, if Fifty Million Gallons per day had been drawn through the Conduit, beginning June 1, 1891.

	All Quantities in Million Gallons.											
	Flow of River per Drainage Area.			Total Natural Flow of River.	Taken from or added to Oak Ridge.	Volume in Oak Ridge.	Taken from or added to Clinton.	Volume in Clinton.	Waste from each Drainage Area.			
	Macopin.	Oak Ridge.	Clinton.						Macopin.	Oak Ridge.	Clinton.	Total Waste.
1891.						2,558						
June 1 to 7 . .	91	94	33	218	— 132	2,426	. . . .	3,539				
8 to 14 . .	73	75	26	174	— 176	2,250	. . . .	"				
15 to 21 . .	39	40	14	93	— 257	1,993	. . . .	"				
22 to 28 . .	44	45	15	104	— 246	1,747	. . . .	"				
29 to July 5	31	30	11	72	— 278	1,469	. . . .	"				
July 6 to 12 . .	25	25	9	59	— 291	1,178	. . . .	"				
13 to 19 . .	21	21	7	49	— 301	877	. . . .	"				
20 to 26 . .	31	31	11	73	— 277	600	. . . .	"				
27 to Aug. 2	38	39	14	91	— 259	341	. . . .	"				
Aug. 3 to 9 . .	32	33	11	76	— 274	67	. . . .	"				
10 to 16 . .	30	30	11	71	. . . .	"	— 279	3,260				
17 to 23 . .	68	70	24	162	. . . .	"	— 188	3,072				
24 to 30 . .	481	492	172	1,145	+ 492	550	+ 172	3,244	131	. .	. .	131
31 to Sept. 6	170	173	60	403	+ 173	732	— 120	3,124				
Sept. 7 to 13 . .	135	139	48	322	. . . .	"	— 28	3,096				
14 to 20 . .	61	62	22	145	. . . .	"	— 205	2,891				
21 to 27 . .	48	49	17	114	. . . .	"	— 236	2,655				
28 to Oct. 4	42	42	15	99	. . . .	"	— 251	2,404				
Oct. 5 to 11 . .	43	44	16	103	. . . .	"	— 247	2,157				
12 to 18 . .	31	31	11	73	. . . .	"	— 277	1,880				
19 to 25 . .	40	40	14	94	. . . .	"	— 256	1,624				
26 to Nov. 1	28	28	10	66	. . . .	"	— 284	1,340				
Nov. 2 to 8 . .	31	31	11	73	. . . .	"	— 277	1,063				
9 to 15 . .	72	73	26	171	. . . .	"	— 179	884				
16 to 22 . .	325	332	116	773	+ 307	1,039	+ 116	1,000				
23 to 29 . .	288	365	118	771	+ 303	1,342	+ 118	1 118				

Flow of Pequannock River, etc. — Continued.

	All Quantities in Million Gallons.											
	Flow of River per Drainage Area.			Total Natural Flow of River.	Taken from or added to Oak Ridge.	Volume in Oak Ridge.	Taken from or added to Clinton.	Volume in Clinton.	Waste from each Drainage Area.			
	Macopin.	Oak Ridge.	Clinton.						Macopin.	Oak Ridge.	Clinton.	Total Waste.
Nov. 30 to Dec. 6	356	307	143	806	+ 307	1,649	+ 143	1,261	6	. .	. .	6
Dec. 7 to 13 . .	279	259	169	707	+ 188	1,837	+ 169	1,430				
14 to 20 . .	153	123	296	472	. . . .	"	+ 122	1,552				
21 to 27 . .	382	437	222	1,041	+ 437	2,274	+ 222	1,774	32	. .	. .	32
28 to Jan. 3	873	755	238	1,866	+ 284	2,558	+ 238	2,012	523	471	. .	994
1892.												
Jan. 4 to 10 . .	469	439	263	1,171	. . . .	2,558	+ 263	2,275	119	439	. .	558
11 to 17 . .	868	868	287	2,023	. . . .	"	+ 287	2,562	518	868	. .	1,386
18 to 24 . .	782	783	248	1,813	. . . .	"	+ 248	2,810	432	783	. .	1,215
25 to 31 . .	333	333	111	777	. . . .	"	+ 111	2,921	. .	316	. .	316
Feb. 1 to 7 . .	226	226	65	517	. . . .	"	+ 65	2,986	. .	102	. .	102
8 to 14 . .	199	200	48	447	. . . .	"	+ 48	3,034	. .	49	. .	49
15 to 21 . .	138	139	47	324	— 73	2,485	+ 47	3,081				
22 to 28 . .	202	203	56	461	+ 55	2,540	+ 56	3,137				
29 to Mar. 6	156	156	87	399	— 38	2,502	+ 87	3,224				
Mar. 7 to 13 . .	361	361	102	824	+ 56	2,558	+ 102	3,326	11	305	. .	316
14 to 20 . .	232	233	98	563	. . . .	"	+ 98	3,424	. .	115	. .	115
21 to 27 . .	288	288	104	680	. . . .	"	+ 104	3,528	. .	226	. .	226
28 to April 3	340	341	100	781	. . . .	"	+ 11	3,539	. .	331	89	420
April 4 to 10 . .	246	247	83	576	. . . .	"	. . . .	"	. .	143	83	226
11 to 17 . .	160	160	80	400	. . . .	"	. . . .	"	. .	. .	50	50
18 to 24 . .	182	182	80	444	. . . .	"	. . . .	"	. .	14	80	94
25 to May 1	58	58	80	196	— 154	2,404	. . . .	"				
May 2 to 8 . .	115	115	80	310	— 40	2,364	. . . .	"				
9 to 15 . .	125	126	80	331	— 19	2,345	. . . .	"				
16 to 22 . .	329	196	83	608	+ 115	2,520	. . . .	"	. .	. .	83	83
23 to 29 . .	377	364	114	855	+ 38	2,558	. . . .	"	27	326	114	467
30 to June 5	523	258	156	937	. . . .	"	. . . .	"	173	258	156	587
June 6 to 12 . .	354	508	131	993	. . . .	"	. . . .	"	4	508	131	643

Flow of Pequannock River, etc. — Continued.

	All Quantities in Million Gallons.											
	Flow of River per Drainage Area.			Total Natural Flow of River.	Taken from or added to Oak Ridge.	Volume in Oak Ridge.	Taken from or added to Clinton.	Volume in Clinton.	Waste from each Drainage Area.			
	Macopin.	Oak Ridge.	Clinton.						Macopin.	Oak Ridge.	Clinton.	Total Waste.
June 13 to 19 . .	145	155	53	353	. . . .	2,558	. . . .	3,539	. .	3	. .	3
20 to 26 . .	165	182	65	412	. . . .	"	. . . .	"	. .	62	. .	62
27 to July 3	139	151	50	340	. . . .	"	— 10	3,529				
July 4 to 10 . .	73	79	26	178	. . . .	"	— 172	3,357				
11 to 17 . .	44	47	17	108	. . . .	"	— 242	3,115				
18 to 24 . .	28	30	10	68	. . . .	"	— 282	2,833				
25 to 31 . .	34	38	14	86	. . . .	"	— 264	2,569				
Aug. 1 to 7 . .	45	48	16	109	. . . .	"	— 241	2,328				
8 to 14 . .	72	77	26	175	. . . .	"	— 175	2,153				
15 to 21 . .	21	26	9	56	. . . .	"	— 294	1,859				
22 to 28 . .	72	82	26	180	. . . .	"	— 170	1,689				
29 to Sept. 4	106	35	23	164	. . . .	"	— 186	1,503				
Sept. 5 to 11 . .	36	26	10	72	. . . .	"	— 278	1,225				
12 to 18 . .	98	105	37	240	. . . .	"	— 110	1,115				
19 to 25 . .	37	42	15	94	. . . .	"	— 256	859				
26 to Oct. 2	12	14	12	38	. . . .	"	— 312	547				
Oct. 3 to 9 . .	17	21	8	46	. . . .	"	— 304	243				
10 to 16 . .	14	16	5	35	— 90	2,468	— 225	18				
17 to 23 . .	16	19	2	37	— 313	2,155	. . . .	"				
24 to 30 . .	16	18	2	36	— 314	1,841	. . . .	"				
31 to Nov. 6	80	23	3	106	— 247	1,594	+ 3	21				
Nov. 7 to 13 . .	80	81	16	177	— 189	1,405	+ 16	37				
14 to 20 . .	419	434	154	1,007	+ 434	1,839	+ 154	191	69	. .	. .	69
21 to 27 . .	133	135	78	346	— 82	1,757	+ 78	269				
28 to Dec. 4	98	105	51	254	— 147	1,610	+ 51	320				
Dec. 5 to 11 . .	218	306	108	632	+ 174	1,784	+ 108	428				
12 to 18 . .	185	207	86	478	+ 42	1,826	+ 86	514				
19 to 25 . .	93	98	49	240	— 159	1,667	+ 49	563				
26 to Jan. 1	122	131	51	304	— 97	1,570	+ 51	614				

Flow of Pequannock River, etc. — Concluded.

	All Quantities in Million Gallons.											
	Flow of River per Drainage Area.			Total Natural Flow of River.	Taken from or added to Oak Ridge.	Volume in Oak Ridge.	Taken from or added to Clinton.	Volume in Clinton.	Waste from each Drainage Area.			
	Macopin.	Oak Ridge.	Clinton.						Macopin.	Oak Ridge.	Clinton.	Total Waste.
1893.												
Jan. 2 to 8 . .	381	413	160	954	+ 413	1,983	+ 160	774	31	. .	. .	31
9 to 15 . .	168	182	75	425	0	"	+ 75	849				
16 to 22 . .	88	94	45	227	— 168	1,815	+ 45	894				
23 to 29 . .	120	130	36	286	— 100	1,715	+ 36	930				
30 to Feb. 5	170	184	58	412	+ 4	1,719	+ 58	988				
Feb. 6 to 12 . .	560	599	160	1,319	+ 599	2,318	+ 160	1,148	210	. .	. .	210
13 to 19 . .	508	546	203	1,257	+ 240	2,558	+ 203	1,351	158	306	. .	464
20 to 26 . .	473	508	115	1,096	0	"	+ 115	1,466	123	508	. .	631
27 to Mar. 5	232	251	75	558	0	"	+ 75	1,541	. .	133	. .	133
Mar. 6 to 12 . .	727	788	204	1,719	0	"	+ 204	1,745	377	788	. .	1,165
13 to 19 . .	1,115	1,195	454	2,764	0	"	+ 454	2,199	765	1195	. .	1,960
20 to 26 . .	650	705	258	1,613	0	"	+ 258	2,457	300	705	. .	1,005
27 to April 2	576	624	288	1,488	0	"	+ 288	2,745	226	624	. .	850
April 3 to 9 . .	452	490	248	1,190	0	"	+ 248	2,993	102	490	. .	592
10 to 16 . .	391	424	170	985	0	"	+ 170	3,163	41	424	. .	465
17 to 23 . .	491	532	225	1,248	0	"	+ 225	3,388	141	532	. .	673
24 to 30 . .	362	389	130	881	0	"	+ 130	3,518	12	389	0	401
May 1 to 7 . .	1,118	1,200	409	2,727	0	"	+ 21	3,539	768	1200	388	2,356
8 to 14 . .	472	506	173	1,151	0	"	0	"	122	506	173	801
15 to 21 . .	400	429	146	975	0	"	0	"	50	429	146	625
22 to 28 . .	191	206	70	467	0	"	0	"	0	47	70	117

THE LOCATION, CONSTRUCTION AND LAYING OF THE 54-INCH STEEL SUBMERGED PIPE IN SKANEATELES LAKE FOR THE SYRACUSE WATER WORKS.

BY

WILLIAM R. HILL, Chief Engineer Syracuse Water Works, Syracuse, N. Y.

Read June 15th, 1893.

In the year of 1889 the Syracuse Water Commission, after a thorough investigation of the various proposed sources, recommended Skaneateles Lake as offering the best water supply available.

Skaneateles Lake is a beautiful sheet of water, located about 20 miles southwesterly from Syracuse. This lake is about 16 miles long, by about three-quarters of a mile wide, having an area of 12.75 square miles and a tributary water shed, exclusive of lake, of 60.28 square miles.

In elevation, the high water line is 867.096 feet above the mean low tide at Albany, New York, 466.40 feet above the level of Syracuse, and 246.40 feet above the flow line of the Distributing Reservoir now being constructed.

The water is taken from the northerly end of the lake by means of a 54-inch steel pipe, extending from the Intake Crib to the Gate House, from which the water is carried by gravity through a 30-inch cast iron pipe, to the Distributing Reservoir in the city of Syracuse.

THE LOCATION.

It has been observed, after a strong southerly wind, that the water in the northerly end of the lake, where it is less than 20 feet in depth, was roiled for a distance of about 4000 feet back from the foot of the lake. Taking this fact into consideration, it was necessary to reach the clear water beyond in as direct a line as possible.

In order to determine upon the location of the submerged pipe line, a hydrographical survey was made, extending from the foot of the lake southerly, for about one and one-half miles. The location of the lake shore and of the base line on the west side, together with taking about 3000 individual soundings, were included in this survey.

In making the soundings, a small steam yacht containing the sounding party of four men, was used. The soundings were taken on parallel lines, extending across the lake from successive 100 foot stations of the base line. Before taking a line of soundings a transitman would set his instrument over the proper station of the base line and give line for anchoring in range on the line of sounding, two buoys, which served as guides for keeping the boat on line.

Beginning at the east shore of the lake and opposite the station of the base line, over which the transit was set, the boat was started on line and soundings taken about 100 feet apart. As each sounding was made, the whistle was blown and the transitman at the station on base line, took an angle on the whistle, as did also a second transitman, who was permanently located at the foot of the lake and in such position, that the line of sight of his instrument would intersect the line on which the soundings were taken, at nearly right angles.

The soundings were measured by means of a steel tape to which was attached a sounding iron, weighing about four pounds. The sounding iron had a concave base which was filled with soap, thus affording a means of obtaining a sample of the material forming the lake bottom. As soon as a sounding was made the recorder, on board the boat, entered in his book the number, the depth and the time. The two transitmen on the shore also recorded the number of the sounding, the angle and the time. From these notes, the three thousand soundings were easily plotted and an accurate contour map of the lake bottom was made, from which the final location of the pipe line was determined.

The contour map of the lake shows the Intake Crib located in 38 feet of water and 6410 from the Gate House on the shore, at the north end of the lake.

Three separate analyses of water taken at the surface directly over the Crib, halfway down, and at the Crib respectively, show the water at the Crib to be the purest, the surface water next, while the sample taken halfway down, ranked third in quality.

THE CONSTRUCTION.

This work consisted of about 6400 linear feet of single riveted steel pipe, having an internal diameter of 54 inches.

This pipe was made by the Groton Bridge and Manufacturing company, of Groton, N. Y., from $\frac{3}{8}$-inch steel plates, weighing 15 pounds per square foot and rolled at the mills of Carnegie, Phipps and Company, at Homestead, Pa.

The plates were each 6 feet wide, and of such length as would form the proper circle of the pipe and the necessary lap of $2\frac{1}{2}$ inches. Five of these 6-foot sections were then telescope joined and riveted to form a rigid section 29 feet 2 inches in length. The edges of the longitudinal seams and of the circular joints, both outside and inside, were beveled and hammer calked until they were made water tight, without plugging or packing, the same as is usually done on first-class boiler work.

These 29 foot sections after being tested and coated with asphalt, were shipped to the delivery grounds on the shore of Skaneateles Lake, where four of these sections were joined and riveted together forming a rigid section about 116 feet in length. On one end of this long section, (Fig. 1)* a spigot of $2\frac{5}{8}$x$\frac{3}{4}$-inch steel, (C) was riveted, while on the opposite end there was a

*Cuts loaned by "Engineering News."

DETAILS

OF

54-Inch Steel Pipe Joints,

Syracuse Water Works,

WILLIAM R. HILL, Chief Engineer.

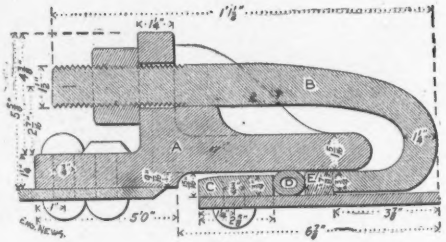


FIG. 1.

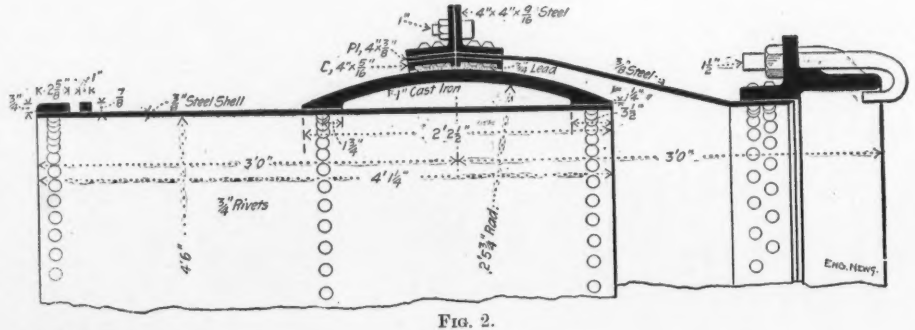


FIG. 2.

cast-iron bell, (A.) On the spigot end there was a 1x⅞-inch wrought iron hoop loosely encircling the pipe, and between this hoop (E) and the steel spigot was placed a soft lead pipe, (D.)

The cast iron bell was provided with twenty steel hook bolts (B) with hexagonal nuts. After entering the spigot into the bell, the hook bolts were brought to bear against the wrought iron hoop which in turn pressed against the soft lead pipe causing it to upset and form a cold lead joint.

There were used on this line, seven universal flexible joints, (Fig. 2)* made from steel plates, channels and angles, on the ball and socket principle, consisting of a turned cast iron hollow zone or ball, working in a spherical lead lined steel socket and capable of a deflection of 12 degrees, in any direction, from the axis of the pipe.

The plates were of mild steel of an ultimate tensile strength of from 55,000 to 65,000 pounds per square inch.

All plates were required to be able to stand the test of punching a row of holes ¾-inch in diameter, pitched 1½ inches between centres, without causing cracks; and to withstand the test of enlarging to the extent of one-third their original diameters, a row of punched rivet holes, centre pitched two diameters from the edge of the plate and three diameters apart, without cracking the sheets.

Strips cut from the sheets lengthwise and crosswise, were required to stand the test of cold bending double, flat under the hammer, without fracture. The plates had to be tough and pliable enough to allow of cold scarfing to a fine edge at the laps, without cracking and to be rolled to the circle of the pipe, without cracking between the rivet holes and the edge of the plate.

The plates were shipped from the rolling mills to Groton on flat cars provided with roofs to protect the steel from rain. After being unloaded, the plates were laid out and hand-pricked for punching from carefully made templets; they were then passed to the punch and then to the chamfering machine where both the side edges of each plate were cut to curves, so that in bending the plate to the circle of the pipe, the ends of the 6 foot telescope section thus formed would be at right angles to the axis of the pipe and have an internal diameter of 54 inches and 54¾ inches respectively. The edges of the plates at the lap were next beveled to a fine edge by hammering and were then passed to the rolls which were so arranged that the plate was formed to the proper circle. As soon as they were thus formed, they were temporarily held in shape by bolts and were then assembled for riveting.

At this part of the shop, there were two parallel hand car tracks, just far enough apart to allow men to work handily between the two cars on which the pipe sections were placed. Over these tracks was suspended an Allen pneumatic riveter.

As soon as the rivets were driven on the pipe section on track No. 1, the riveter was swung over track No. 2, where in the meantime another section had been put in position by the assemblers. Then while the riveter was

*Cuts loaned by "Engineering News."

working over track No. 2, the assemblers placed another section in position on track No. 1. This rotation was kept up until five 6-foot sections had been riveted together, making a 29-foot section. These long sections were then placed on skids in another part of the shops, where the seams were calked with a pneumatic tool and the pipes thoroughly cleaned from all scales or dirt. They were then inspected and taken to the dipping tank to receive the asphalt coating.

The dipping tank was made of ¼-inch steel plates and was 31 feet long by 5 feet 6 inches wide by 5 feet 6 inches deep, having the bottom rounded and fitted with rolls to allow the pipe to be revolved in the bath. Extending underneath and supporting this tank, was a brick furnace fitted with an ordinary grate for burning wood. The coating was a mixture of the Los Angeles Oil Burning Supply Company's dry asphalt, Grade D, and their liquid asphalt Grade G. To start a dip, it was necessary to use three parts of D to one part of G; but once started it was necessary to add the Grade G only.

The temperature of the mixture was tested by immersing in the boiling mass a piece of ⅜-inch steel plate about six inches square, which was allowed to remain therein about ten minutes, when it was removed and immediately cooled in ice cold water. If the coating did not then crack or fly off upon striking the plate with a hammer and did not soften at a temperature of 100 degrees Fahr. it was considered to be of the proper temper.

The pipe was then completely submerged in the bath, and left therein at least 20 minutes, or long enough for the steel to attain the temperature, not less than 280 degrees Fahr., of the mixture. It was then withdrawn, and the coating allowed to stiffen for a few moments, and then again immersed a short time to thicken the coat.

The pipes were raised and lowered into the bath by means of a derrick. It required about 45 minutes to properly coat one of the 29-foot sections.

THE LAYING.

The contract for laying the submerged pipe, was awarded to Messrs. Hingston & Chapman, of Buffalo, N. Y. Before laying any pipe they constructed a catamaran 95 feet long, 30 feet wide and 6 feet deep. This was made in two sections, each 95 feet long and 12 feet wide. The sides and ends of each section were formed entirely of 6"x12" oak timbers placed on top of each other and secured by bolts. These two sections were placed side by side and 6 feet apart and held in this position by five 12"x14" oak timbers. Each section was covered by a plank floor, but the 6-foot space, between the two sections, was left open.

Over this opening were arranged three timber supports for the pulley blocks from which a length of pipe could be suspended.

The Intake Crib, 16 feet square and 12 feet deep, was constructed of 10"x12" oak timbers, dovetailed and secured by 1¼ inch rods. This crib containing a short bell mouth section of the intake pipe, having a flexible joint attached to its outer end, was built on board the catamaran, and after being carried out near where it was to be anchored, it was launched and floated in position

between four guide piles. Stone ballast was then added until the Crib sunk upon the broken stone foundation, which had already been prepared. After the Crib had been placed, a section of the steel pipe, the ends of which had been closed by oiled canvas, was rolled off the skids into the water and floated out to the catamaran which was held in position by spud piles over where the pipe was to be lowered. The pipe was then drawn into the open space between the two sections of the catamaran where the timber saddle pieces were fastened to the pipes and the ropes and tackling adjusted.

Upon removing the oil canvas bulkheads, the pipe filled with water and supported by the ropes, it was lowered into position on the lake bottom. Before the ropes were removed, the divers entered the spigot into the bell, adjusted the hook bolts and by screwing up the nuts, upset the lead pipe and formed the joint.

The booms from which the pipe was suspended, were so constructed that the pipe could also be moved longitudinally. As the catamaran was made so large and of such heavy timbers there was no trouble experienced from unsteadiness, except when the water was very rough; however under ordinary conditions, the contractors were able to lay one of the 116-foot sections in one day.

The total cost of the steel pipe, including the flexible joints, delivered on the skids at Skaneateles Lake, was $8.80 per linear foot and the contract price for laying the same was $2.50 per linear foot.

Owing to the trench not being dredged, the pipe laying was suspended last fall and there still remains about 2000 feet of the pipe to be laid in the Lake. This dredging is now nearly finished and the pipe laying will be resumed about the first of July.

All of the 30-inch cast-iron pipe for the conduit line from the Lake to Syracuse, will be delivered by August 15th, and pipe laying is now in progress on all four sections of this line. The work on the new Distributing Reservoir is also well under way but will not be completed until the fall of 1894.

It is expected, however, to have Skaneateles Lake water into the present Reservoir before the end of the current year.

THE PURIFICATION OF WATER BY FREEZING.

BY

THOMAS M. DROWN, Professor of Analytical Chemistry, Massachusetts Institute of Technology, Boston.

[Read June 15, 1893.]

The rapid growth of the artificial ice industry, and the claim frequently made that artificial ice is much purer than natural ice, makes it desirable that the relation between the quality of ice, and the quality of water from which it is formed, should be fully understood.

Freezing of water is ordinarily a process of purification, that is to say, the ice is usually purer than the water which is frozen. And yet, under certain conditions of freezing, the ice may contain the impurities of water in a highly concentrated condition.

The purification of water by freezing can be best observed in nature, when ice is formed slowly on deep ponds in winter. Laboratory experiments on the freezing of water containing known amounts of various substances in solution, are generally less satisfactory because the abstraction of the heat of the water by freezing mixtures is usually very rapid, and also because the amount of water experimented with is comparatively small.

In the formation of ice on deep ponds in winter, it is the surface only that is affected, and the rate of freezing decreases as the ice increases in thickness. The water freezes very slowly after the ice is a few inches or more in thickness, and it is under these conditions that the greatest purification—that is to say, the most perfect elimination of the substances in solution in the water—takes place.

The State Board of Health, of Massachusetts made, a few years ago, a very thorough investigation of the ice supplies of the State,* and many interesting facts with regard to the purification of water by freezing were then determined.

A sample of ice from an unpolluted pond was found to be purer than most distilled water, it had no color, no free or albuminoid ammonia or nitrites, and contained only 0.2 part of mineral matter per 100,000 [equal to 0.1 grain per gallon] and .0050 part of nitrogen as nitrates. This ice was formed from water which had 3.15 parts of mineral matter, .0192 part of albuminoid ammonia, 0.44 part of chlorine, and 0.0100 part of nitrates. Among the 275 analyses of ice and water made in the course of this investigation, there were many instances where the degree of purification was as great as the one cited. In as many cases as possible the comparison of the

*Twenty-first Annual Report pp. 143-223.

water and ice was made by cutting out a piece of ice from the pond and then taking a sample of water from the opening made in the ice. Where ice harvesting was in progress corresponding samples of water and ice were easily obtained. The following table contains the average composition of ten samples of water and the corresponding ten samples of ice. In each case the water and ice were collected at the same time, as above described. Some of the ponds and rivers included in these averages were unpolluted, but the majority of them contained considerable sewage or the drainage of houses or stables. The determinations were made on the melted ice after filtering through paper.*

COMPARISON OF TEN BODIES OF WATER AND THE CORRESPONDING ICE.

Parts per 100,000.

	Color.	Fixed residue.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Nitrogen as	
						Nitrates.	Nitrites.
Water.....	0.3	6.075	.00864	.01350	.617	.0430	.00060
Ice.....	0.0	.391	.00112	.00108	.010	.00430	.00003
Percentage remaining in Ice.	0.	6.4	13.	8.	1.6	10.	.5

In the above cases the comparison is made between the water and the whole mass of ice. A comparison between the water and the bottom portion of the ice would generally show a still higher purification. It is not at all uncommon in the bottom ice to find free and albuminoid ammonia and chlorine entirely absent. This is not often the case in the top ice, and snow ice is generally quite impure.

The progressive improvement in the quality of the ice from the top downwards is well shown in the following analysis of a block of ice which was divided into five layers.

*It is important that the ice be melted without contact with the air of the laboratory. This may be accomplished by putting fragments of ice, after washing with distilled water, into a wide-necked bottle, and allowing the ice to melt after closing the bottle with a glass stopper. The fragments of ice must not be touched with the hands.

ANALYSIS OF ICE IN FIVE LAYERS.

Thickness of Ice 9 Inches.

Parts per 100,000.

	Fixed Residue.	Free Ammonia.	Albumin. Ammonia.		Chlorine.
			In Solution.	In Suspension.	
Top layer with snow ice.....	1.10	.0080	.0048	.0166	.02
Second layer.....	0.50	.0034	.0012	.0056	.02
Third layer.....	0.55	.0016	.0008	.0032	.01
Fourth layer.....	—	.0016	.0008	.0022	.00
Fifth layer.....	0.05	.0012	.0002	.0006	.00

We may fairly conclude from the above that the degree of purification in freezing is dependent on the rate, the slower the process the more complete the elimination of the dissolved and suspended matter in the water.

From this series it is also apparent that there is a progressive improvement in the ice as it increases in thickness as regards the *suspended* impurities. When the ice is forming quickly the suspended matter in the water is probably entangled to a greater or less extent in the ice crystals. In a case in which a body of sewage was frozen to a depth of one inch, the ice contained only five per cent. of the dissolved organic matter [as indicated by the albuminoid ammonia], while it had 28 per cent. of that which was in suspension.

As regards the bacteria there is also progressive improvement in the quality of the ice from above downwards as might be expected from the above results. The bacteria determinations made in connection with the chemical analyses in these investigations showed that the snow ice contained as many as 81 per cent. of the bacteria of the water, and the clear, bottom ice only two per cent. This large removal of bacteria may, of course, be partly due to their destruction by long continued cold, but the researches of Dr. Prudden, Dr. Billings, and others have shown that many specific bacteria resist the action of cold for a very long time.

The greater impurity of the top ice may be due to various causes. The ice first formed on a surface of water more or less ruffled by the wind will enclose, doubtless, more of the impurities of the water than when freezing goes on more slowly and quietly. Again, the surface of the ice may be flooded by

the water from below; this is often intentionally done by ice cutters. When this water is frozen solid there is, of course, no opportunity for the elimination of dissolved matter. Further, the dust and dirt of various kinds which fall upon the ice, especially on ponds near cities, the impurities which snow brings down out of the atmosphere, and the contamination of the surface by men and horses at the time of ice cutting, all tend to render the surface ice impure.

If a block of ice from a pond near a city or railroad, with snow, or very porous ice on the top, is divided, and the upper and lower portions allowed to melt separately, in clear white glass bottles, the difference in their character is very strikingly shown. The water from the surface deposits generally a very considerable amount of sediment, the greatest part of which is black, looking like soot or cinders, while the bottom portion is often free from turbidity and sediment. When snow, which has fallen in cities is melted, the water is very dirty, and smells strongly of soot.

The elimination of the impurities of water when it freezes, is necessarily accompanied by a concentration of the impurities in the water itself. Ordinarily in a pond of considerable depth, this concentration would be relatively so slight that it would not be noticed. In two cases, however, where I examined samples of water immediately under the ice, they had a deeper color and more organic matter than the water taken at greater depths, showing, apparently, that the organic matter which had been expelled from the water by slow and undisturbed freezing had accumulated under the ice and had not yet mixed with the great mass of water in the pond.

When a shallow pond freezes to the bottom, it is evident that the ice last formed must contain the greater part of the impurities of the whole body of water. So great is the tendency to purification in freezing that it is in the lower few inches of ice that one must expect to find the greater part of the impurities in cases where the whole body of water is frozen solid.

A not uncommon practice in places where there are no natural ponds, is to flood low ground before cold weather comes on in order to gather an ice crop. When such a shallow pond freezes solid, the organic matter which the water has soaked out of the ground must be in a highly concentrated state in the bottom ice.

It is not improbable in some of the cases in which ice has been known to be the cause of sickness that it was cut from shallow ponds with dirty bottoms. The well known epidemic at Rye Beach, N. H., in 1875, is a case in point. The ice which caused the trouble was cut from a flooded marsh, the water being only two feet deep and containing a good deal of sawdust.

In the ordinary process of making artificial ice the whole mass of water is frozen, and consequently if the water used is not pure we must expect a concentration of the impurities in the portion last frozen. Large cans of galvanized iron, of a capacity of 200 to 250 pounds of water are filled with water and exposed on the outside to a circulating solution of brine which is cooled below the freezing point of water. About two days are required to freeze this

quantity of water to a solid block. The ice first forms on the sides of the can and gradually increases in thickness until the whole mass is solid.

I have recently made some analyses of blocks thus frozen, to determine the distribution of the mineral and organic matter The blocks were divided into six portions, namely, an upper, middle and lower portion of the outside, and an upper, middle and lower portion of the interior core. It was found in all cases that the lower portion of the core of the block contained the greater portion of the impurities of the water. One would naturally suppose that the middle and upper portion of the core would contain the greatest amount of the impurities (as is the case of the segregation of the impurities in the cooling of a steel ingot), but there were some conditions of cooling in the cakes of the ice blocks which determined the portion near the bottom to be the last frozen.

The most interesting case of this segregation was noticed in the freezing of a well water which contained a considerable amount of mineral matter in solution. On page 51 are the analyses of the water used and of the different portions of the ice cake:

These analyses are very interesting and instructive. In this one block of ice, weighing 200 pounds, are portions of high purity, and other portions which contain an amount of mineral matter greater than is desirable in a good drinking water. It is not improbable that the ice from the lower portion of the core would produce intestinal disturbance in those accustomed to soft water. Not only was the mineral matter concentrated in the portion last frozen, but the small amount of organic matter in the original water was also found here.

One might be sorely puzzled to interpret the analysis of this concentrated portion of the ice block, if he did not know its origin. Judged as a sample of water the explanation might well be that it was a tolerably well purified effluent of highly concentrated sewage!

Another interesting fact with regard to this portion of the ice was that on being melted, the water contained a large amount of white suspended matter, which on analysis proved to be silica.

Samples of ice made from distilled water were also examined. The amount of dissolved matter in distilled water is extremely small, yet the process of concentration is, even in such cases, generally noticeable. Thus in one instance where distilled water was frozen the chlorine was increased from .02 part per 100,000 in the water to .33 part in one portion of the ice.

It is interesting in this connection to mention that a sample of distilled water taken from the rubber hose used to fill the cans had a slight odor of rubber. This odor was distinctly perceived in the lower portion of the ice block (when melted), but was not noticed in any other portions of the ice.

From the above we may conclude that the claim for purification by freezing can only be admitted when a mass of water is partially converted into ice. When a body of water is completely frozen, whether in a pond or in a can, the ice as a whole has the same composition as the water itself. Under these

WELL WATER, BOILED AND FILTERED, USED FOR FREEZING.

	Appearance.			Odor.		Total Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Oxygen Consumed.
	Turbidity.	Sediment.	Color.	Cold.	Hot.		Free.	Albuminoid.		Nitrates.	Nitrites.		
	None.	None.	0.00	None.	None.	18.04	.0110	.0010	3.45	.7500	.0200	4.4	.0547
	BLOCK OF ICE.												
Outer layer, upper third.	None.	Sl't, dark-colored particles.	0.00	None.	None.	0.44	.0044	.0008	0.04	.0000	.0062	0.0	.0073
Outer layer, middle third.	None.	None.	0.00	None.	None.	0.24	.0032	.0002	0.05	.0000	.0000	0.0	.0109
Outer layer, lower third.	V.slight.	Cons., white.	0.00	None.	None.	4.00	.0052	.0000	0.44	.1100	.0030	1.6	.0036
Inner core, upper third.	None.	Slight, white.	0.00	None.	None.	4.48	.0102	.0000	0.72	.1800	.0130	1.4	.0255
Inner core, middle third.	V.slight, white.	Cons., white.	0.00	None.	None.	14.76	.0262	.0016	3.27	1.0000	.0700	4.9	.0730
Inner core, lower third.	Distinct, white.	Heavy, white.	0.03	None.	Faintly, earthy.	70.60 61.10*	.0602	.0082	11.59	1.0000	.2800	21.0	.2993

*The second determination of the total residue of evaporation was made on the water filtered through paper in the laboratory.

conditions the impurities cannot be eliminated, but they are redistributed, the ice first formed being very pure, and that last formed containing nearly all the impurities.

In deep ponds we find the ice, which has formed slowly, to be of good quality even when the water itself is quite impure. In shallow bodies of water we should have very pure water and clean ground if the ice is to be above suspicion. In the case of artificial ice, it is absolutely necessary that the water should be of the highest purity. It would be seldom that a well or spring water could be found which would not give an objectionable degree of concentration of mineral matter in the portion last frozen. Distilled water leaves nothing to be desired as regards purity, and the manufacturers of artificial ice will find it desirable to limit themselves to its use.

In all cases of artificial ice which I examined there were practically no bacteria in the water used, or in the ice. It is the general practice in making artificial ice to boil the water in order to expel the air, otherwise the ice block would be very porous from air bubbles and would look more like a cake of compact snow.

OBITUARY.

SHERMAN E. GRANNISS.—Died at New Haven, Conn., August 10th, 1893, aged 58 years, 8 months. Joined this Association June 21st, 1882.

For eighteen years previous to his death Mr. Granniss had acceptably filled the position of superintendent to the New Haven Water Company. He was one of the twenty-seven who organized this Association at Boston, Mass., on June 21st, 1882. He took a deep interest in all its affairs, was a frequent attendant at its meetings, and was well known to all the membership. He served as member of the Executive Committee during the year ending June, 1885, and as one of the Vice Presidents during the years ending June, 1884, and 1886, and was an incumbent of that office at the time of his demise. He was a true friend and valued counsellor, and will be greatly missed in future gatherings of this Association.

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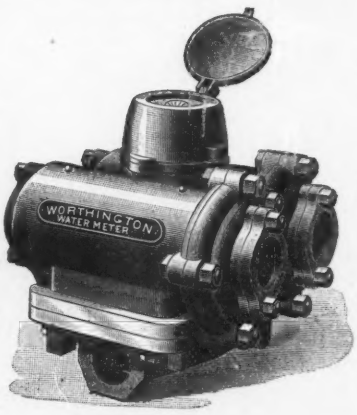

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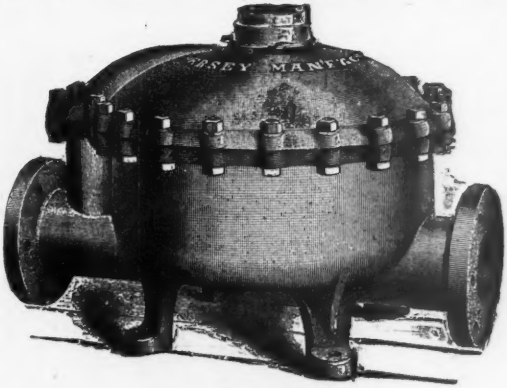

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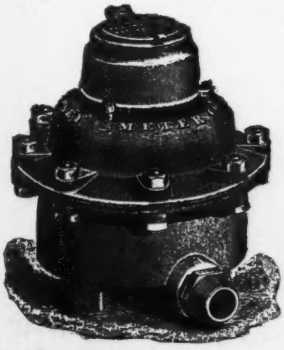

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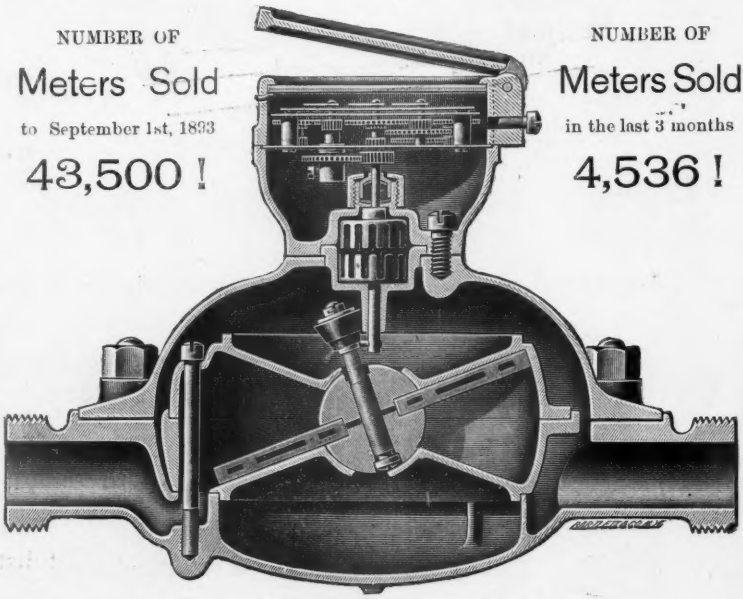

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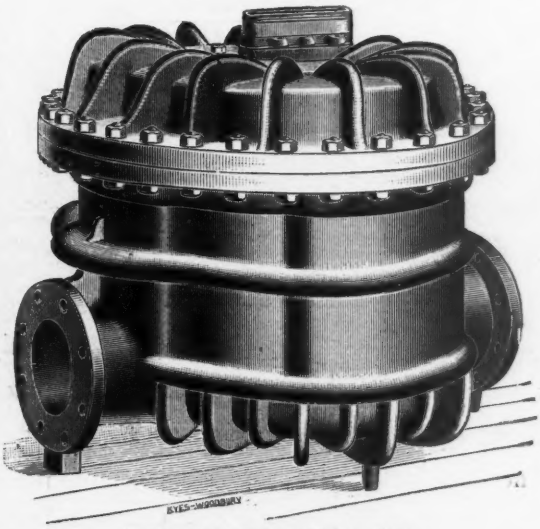

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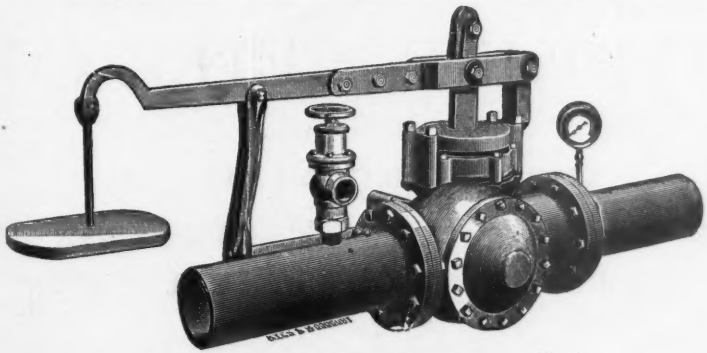

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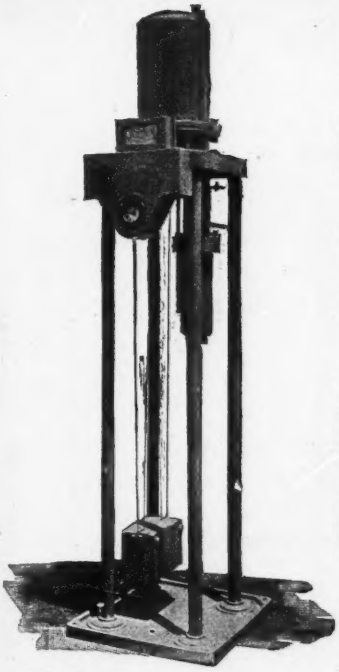

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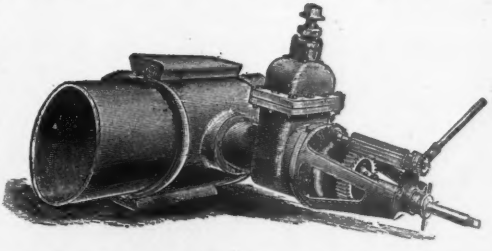

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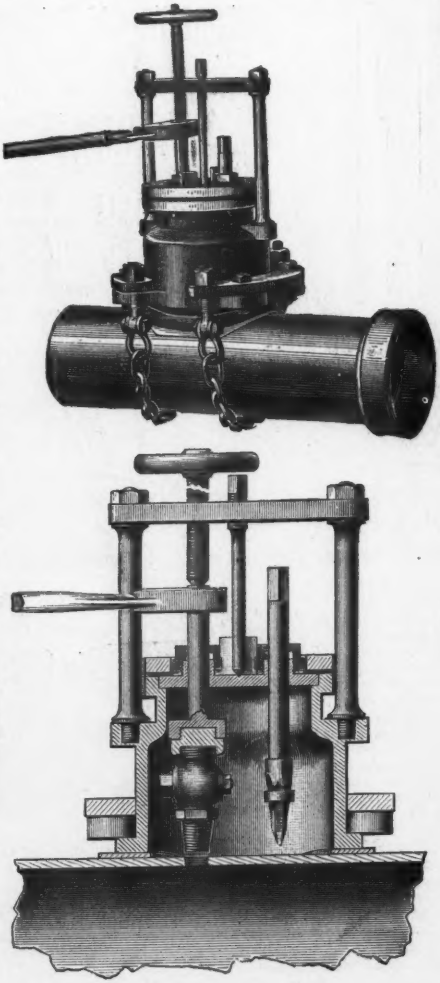

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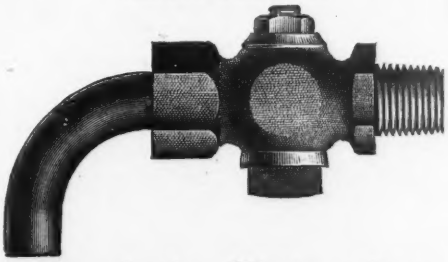

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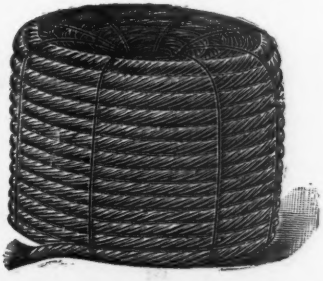

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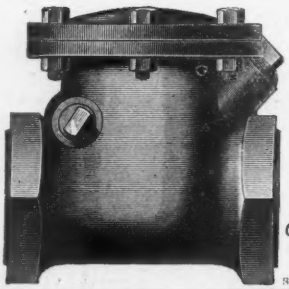

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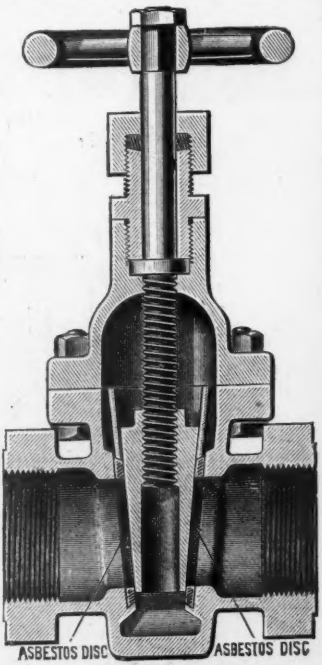

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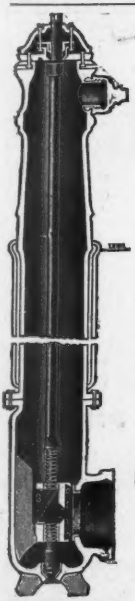

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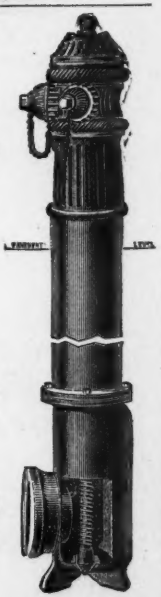

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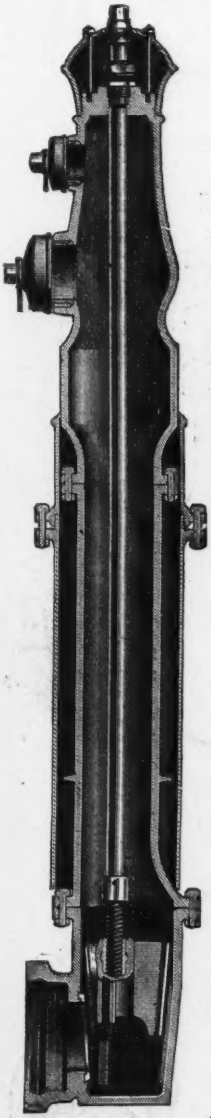
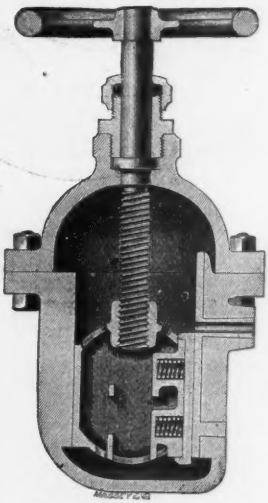
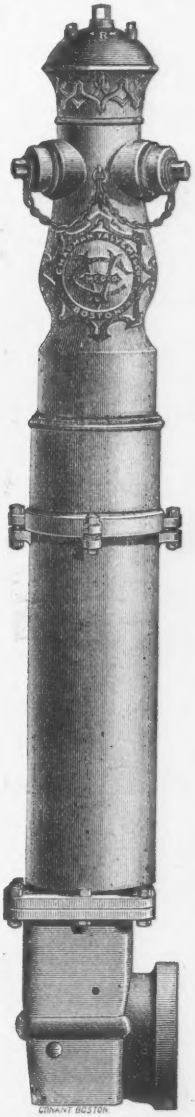


Section Hydrant.

Bell End Water Gate.



Section Drip Valve.



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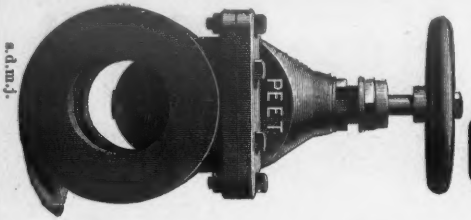

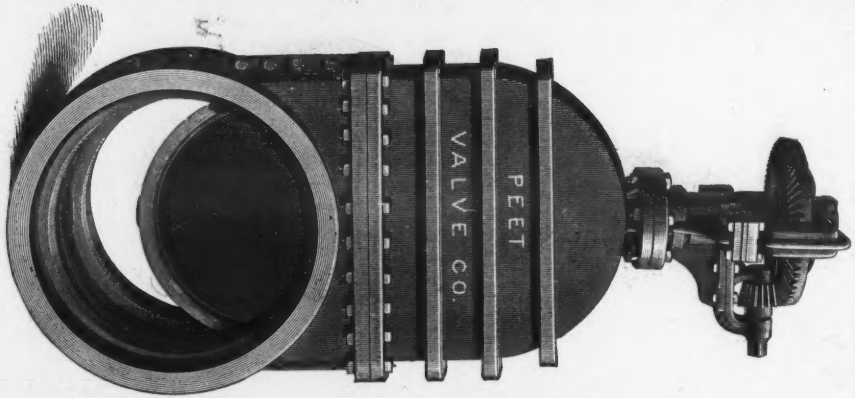

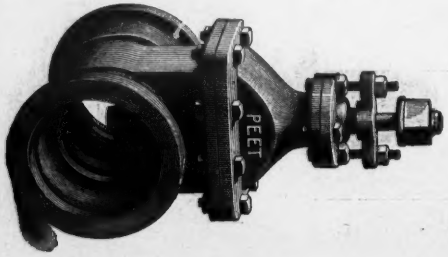

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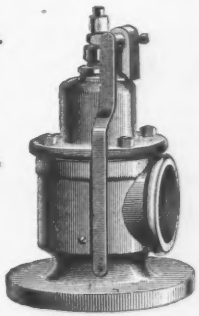

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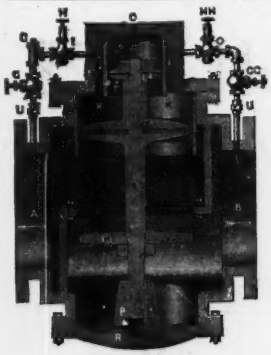

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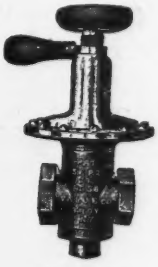

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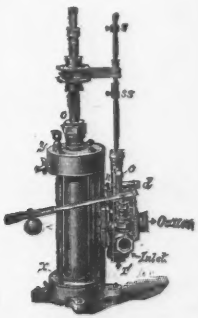

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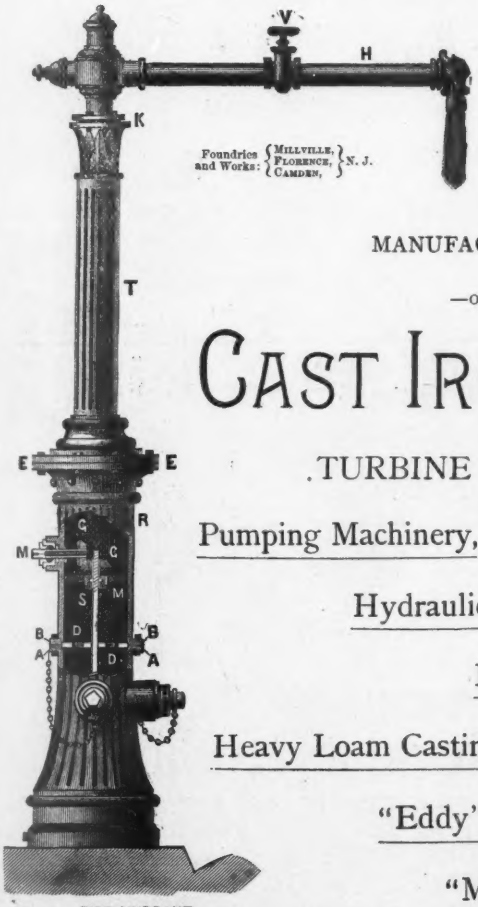

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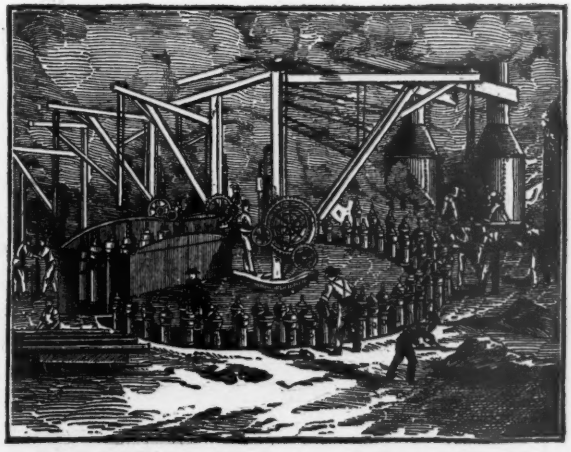

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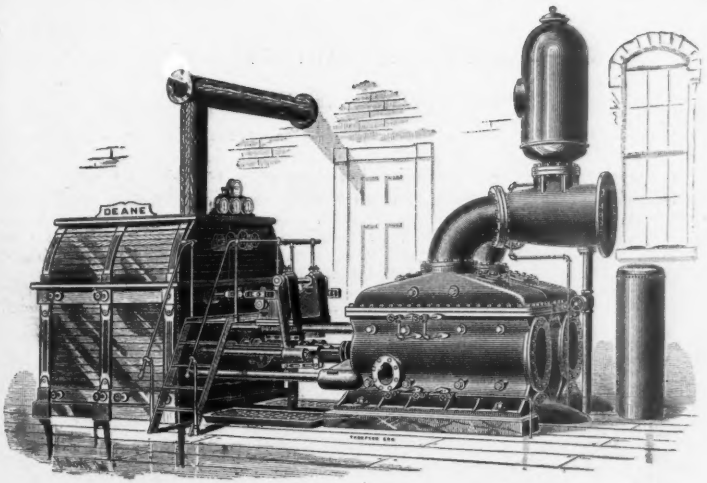

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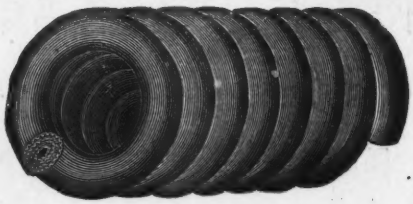

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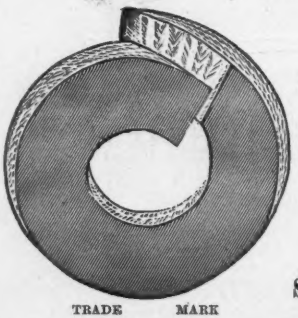

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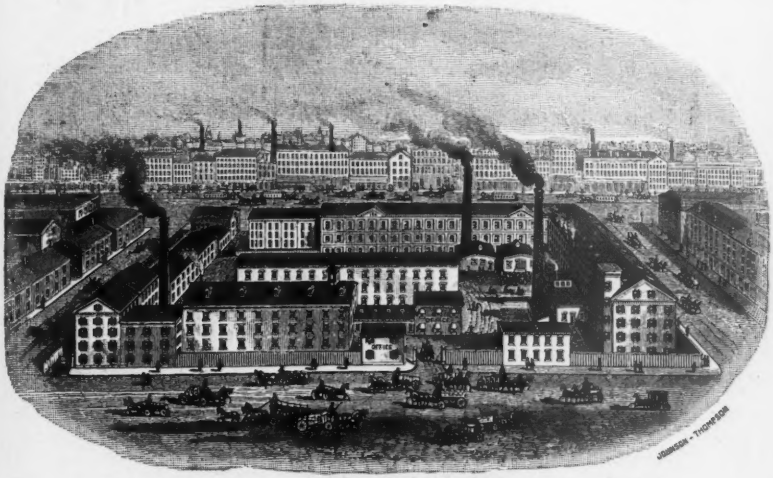

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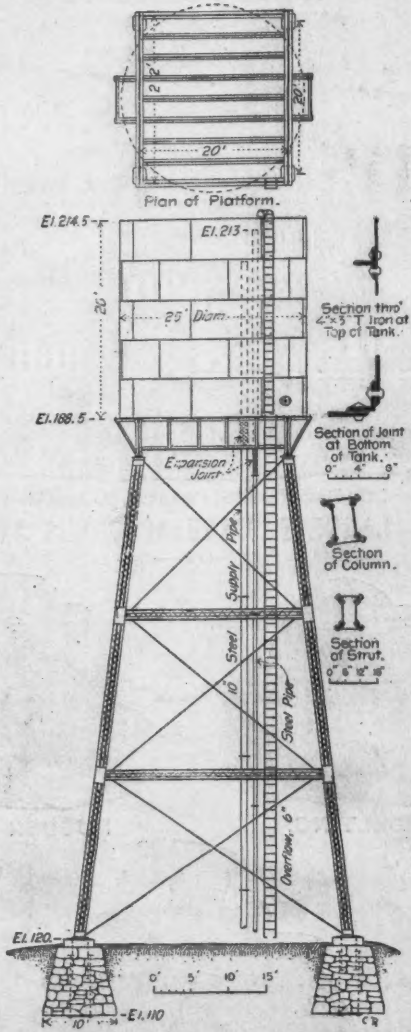

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